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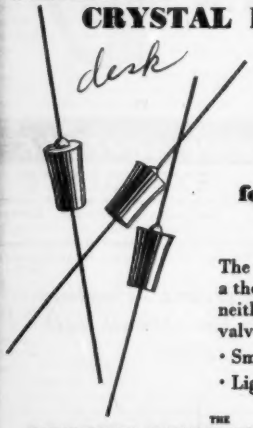

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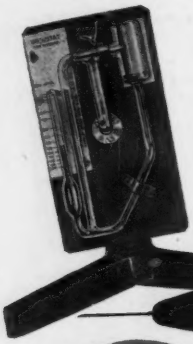

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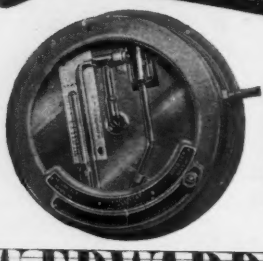

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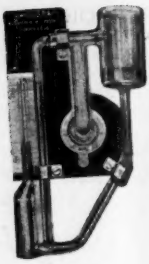

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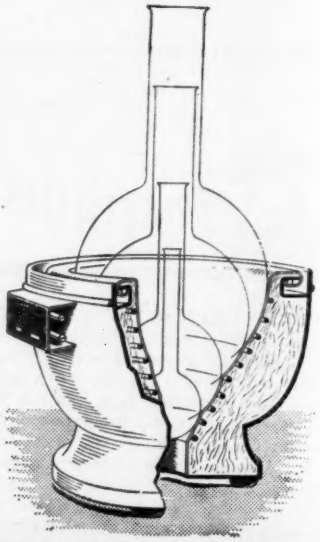

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CONTENTS

	Page
Human Relations in Industry	841
Chemistry of the Earth. By Prof. K. C. Dunham	843
Democratic Planning and Liberty. By R. Brightman	844
University of Manchester, 1851–1951. By Prof. A. D. Ritchie	846
Law of Copyright and Industrial Designs. By R. G. Lloyd	847
Society under the Microscope. By Prof. T. H. Marshall	847
Artificial Acceleration of Atomic Particles. By Prof. O. R. Frisch, O.B.E., F.R.S.	849
Preservation of Biological Materials by Freeze-drying. Dr. R. J. C. Harris	851
Dry Oxidation and Wet Corrosion. By Dr. U. R. Evans, F.R.S.	853
Obituaries:	
Dr. Harald Blegvad. By Dr. Erik M. Poulsen	855
Dr. E. G. V. Percival. By Prof. E. L. Hirst, F.R.S.	855
News and Views	856
Pre-Breakdown Discharges in D.C. Positive Point to Plane Corona. By H. M. Gaunt and Dr. J. D. Craggs	859
Superposition Effects in Multiple-beam Interference Fringes. By Audrey M. Glauert	861
Racial Studies. By Cedric Dover	862
Effects of DDT upon Different Species of Mosquitoes in Malaya. By J. A. Reid	863
Evaluation of Chemotherapeutic Remedies	865
Importance of Science in American Education	866
Current Trends in General Psychology. By Prof. J. Drever	866
British Medicine and the Continent, 1600–1850	867
Letters to the Editors:	
The Term 'Regular Solution'.—Prof. Joel H. Hildebrand	868
Change of Resistivity of Gold by Cold-working at Liquid-Air Temperature and its Recovery by Temporary Heating.—Prof. M. J. Druyvesteyn and J. A. Manintveld	868
Elastic Constants of Alkali Halide Crystals.—Sir K. S. Krishnan, F.R.S., and Dr. S. K. Roy	869
Calibration of Geiger–Müller Liquid Counters by the Radioactivity of Potassium-40.—Dr. T. A. Chalmers	870
Propagation of Very-High-Frequency Radio Waves.—E. Heaton Jones	870
Reduction of Static Electrification by means of Inhibiting Compounds.—G. W. Graham	871
Temperature Dependency of Half Line-Width in Ferrite.—Prof. Tosihiko Okamura and Yosiharu Torizuka	872
Hüttig's Adsorption Isotherm.—Otto Theimer	873
A New Route to Azulenes.—Dr. E. A. Braude and W. F. Forbes	874
Some Trithiocarbonate Derivatives of Carbohydrates.—G. P. McSweeney and Prof. L. F. Wiggins	874
Tetrabromothiophene from 2-Bromothiophene by means of Sodium Acetylide in Liquid Ammonia.—A. Vaitiekunas and Prof. F. F. Nord	875
Urea as a Solvent.—Dr. Robert E. D. Clark	876
A Rapid Method for the Determination of Nucleic Acid Components by Paper Partition Chromatography.—Jan-Erik Edström	876
Identification of Sulphonamides on Paper Chromatograms.—Alan E. Steel	877
Phenolases in the Echinoid, *Diadema antillarum* Philippi.—Prof. N. Millott and F. W. Jacobson	878
Potentiation by Adrenocorticotrophin of the Diabetogenic Action of Growth-Hormone Preparations.—Dr. E. Reid	878
Low Toxicity of the Diphtherial Culture Filtrate and its Relation to the Absence of Tyrosine in the Medium.—Masahiko Yoneda	879
Factor *Rb* Activity in Human Plasma.—Dr. Ellsworth C. Dougherty	880
The Rabbit Lumbrical: a New Isolated Mammalian Nerve–Muscle Preparation.—D. J. Jenden, K. Kamijo and D. B. Taylor	880
Selenium Toxicity associated with an Irish Soil Series.—T. Walsh, G. A. Fleming, R. O'Connor and A. Sweeney	881
Heat Tolerance in European Breeds of Cattle Exposed to High Environmental Temperatures.—J. Dobinson	882
Tone Sensation produced by Repetitive Trains of Auditory 'Click' Stimuli.—W. T. Catton	882

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HUMAN RELATIONS IN INDUSTRY

SOME passages in Prof. C. A. Mace's presidential address to Section J (Psychology) at the Edinburgh meeting of the British Association bear so closely on current problems, and notably on that of productivity and industrial relations in industry, that they deserve attention from a much wider audience than that of the psychologists to whom they were originally directed. Prof. Mace remarked, for example, that the collective personality of a group of professional scientific men, the relations within such groups, and the relationship of these groups to other groups in society as a whole, determine the social function of each science as well as the extent of its responsibilities and powers. Moreover, in Great Britain, political and scientific institutions have developed as mutually reinforcing systems, and he suggested that the health and efficiency of any professional body depends in some measure on the quality of the laity it serves. Given the integrity of the particular professional discipline or science, its efficacy depends also on the existence of a critical and educated laity.

The absence of this condition, at least in part, has handicapped progress in productivity and in dealing with problems of human relations in industry; but it is true also in the sphere of science generally that the effective utilization of scientific knowledge depends upon a wider and clearer understanding of what science is and what it is really doing. There is a political if not a social climate that has to be taken into account. Prof. Mace considers with some justification that the failure to apply the results of research in the field of the human and social sciences is due mainly to the lack of professional men and technologists who combine experience and training in certain basic skills of application with the relevant basic scientific qualifications. But it is equally clear from discussions on productivity—even from that on higher technological education in relation to productivity to which Prof. Mace referred—that the attitude and understanding of labour as indicated by the trade unions is an important factor. The evidence of a change in this attitude provided by the support afforded by the Trades Union Congress to the work of the Anglo-American Council on Productivity, and the unanimity which has marked the reports coming from the productivity teams, is one of the most hopeful signs for the future.

Prof. Mace himself seems to recognize this factor, for it is implicit in the suggestion he makes for fundamental research into the basic conditions of 'status' and 'prestige'. Prof. Mace believes, for example, that it would be worth while to investigate thoroughly the reasons for the common belief in Great Britain that a career in applied science in industry is in some way inferior to that in other professions; but, in addition, he suggests that it would be worth studying carefully also what lies behind the apparent reluctance of university students, at particular times, to enter particular careers like teaching or industry. The historical reasons for the drift to particular occupations—to Whitehall, to

Harley Street, to the Inns of Court—are in part psychological reasons, and as such they require attention.

The relevance of Prof. Mace's address to the question of human relations in industry would thus have been sufficiently manifest had he not specifically referred to poor human relations between management and the factory being detrimental to co-operation in production, and to both industry and commerce suffering from poor public relations between business and the professions. His argument finds ample support both in the two pamphlets, "The Extent of Centralisation"* which the Acton Society Trust has since published in its series of studies of nationalized industry, and in the Beckly Social Service Lecture, "Christianity and Human Relations in Industry"†, which Sir George Schuster delivered to the Methodist Conference in July.

Prof. Mace urged that psychologists have a special responsibility, first for the maintenance of the British tradition in the popularization of science, and second for the preservation of a common medium of communication. This duty of communicating understanding, above all to those who are concerned in any way with the management of men, is one of the most interesting points to be found in Sir George Schuster's analysis, from a Christian point of view, of human relations in industry. Sir George is as convinced as Prof. Mace of the imperative need for clear interpretation of scientific findings, as indeed of religious truths, in terms which can be understood by ordinary people. He will have no truck with the superficial. All the width of his experience as an industrialist, as chairman of the Sub-Committee on War Production of the Select Committee on National Expenditure, and as one of the 'working party' for the cotton textile industry and of the Panel on Human Factors of the Committee on Industrial Productivity gives authority to his statement of the case for enlightened management, and his plea both for the humanizing of management and for a fuller response from the trade union side.

The larger part of Sir George Schuster's lecture is concerned with the relationship of management to workers, and with the contribution which management can make towards establishing industrial employment as an essential part of a satisfying human life, in which there is sufficient scope for personal self-expression and personal responsibility. He insists that human values must not be sacrificed either to efficiency or inefficiency: efficiency, in fact, provides the real basis for confidence and co-operation, and this is no less true on the workers' side than on that of management. Efficiency, understood in the Greek sense of excellence, is an end itself.

As to the organization which will best secure such a purpose, Sir George Schuster has little to say beyond that every decision should be taken at the most effective level—the level where, as Mary Follett would have put it, the decision can be seen to be the demand of the situation; and like Mary Follett and Elton Mayo, he believes that the most important problem in modern industrial organization is to discover the most appropriate working group for each organization. Of even deeper interest to the man of science are his observations on the way in which scientific study is improving working conditions, eliminating hazards to health and assisting to establish better relations between workers and management. Sir George is convinced that there is a wide field of study here, including not only industrial health in the broadest sense, the fitting of the job to the man and, conversely, the fitting, by selection and training, of men to the job, and the assessment of the job, but also human relations and human behaviour. In this connexion, scientific investigation could build up a body of knowledge of immense value for the increase of productivity and of industrial efficiency in the truest sense.

If such study, however, is to replace the subjective opinions and assumptions on which judgments and policies are now too frequently based, we must be on our guard against any tendency in such research to accept men merely as units for providing data for hypotheses and conclusions. Above all, in studying human relations and human behaviour, each individual must be treated with sympathy and understanding as a unique personality. The limitations as well as the possibilities of the scientific method have to be kept in mind.

Sir George Schuster's experience leaves him full of confidence that this intellectual approach can succeed. There is less resistance than even a generation ago, though the public interest in the scientific approach is not without misunderstanding as to what science can and cannot do. Moreover, he believes that success is possible without a complete change of the economic system, given the outlook and approach which he postulates on the side of the workers as well as on that of management.

The approach that Sir George advocates is obviously in harmony with Christian teaching; but the distinction from scientific humanism in general is not manifest. Nevertheless, the Lecture shows how such a policy could contribute to the creation of the atmosphere in which right human relations are established. The first step must come from the side of management, but it cannot suffice without an adequate response on the workers' side. In insisting on the necessity for at least a philosophical, if not a religious, basis for a full life, Sir George roundly challenges the inadequacy of the materialistic outlook which has shipwrecked so many promising ventures in industrial co-operation in the past. We need a sound moral attitude, and unless that is forthcoming the instruments which science provides for the increase of industrial productivity and raising of standards of living are as liable to be used for evil as for good. On this question of values, all our attempts to further co-operation in industry by joint consultation and other methods, no matter how much hard intellectual effort and scientific study are put into the study of concrete problems of industry, may

* The Extent of Centralisation: a Discussion based on a Case Study in the Coal Industry. (Nationalised Industry Series 6 and 7.) Part 1. Pp. ii+20. Part 2. Pp. iii+21–44. (Claygate: Acton Society Trust, 1951.) 2s. each Part.

† Christianity and Human Relations in Industry. By Sir George Schuster. (Beckly Social Service Lecture.) Pp. 128. (London: Epworth Press, 1951.) 6s. 6d. net.

well founder. Without general acceptance of a common scale of values, there can be no co-operation or common purpose.

The analysis of the organization of the coal industry made by the Acton Society Trust points to much the same conclusions as are drawn by Sir George Schuster, as well as supporting Prof. Mace's observations on the importance of human relations, and particularly of status and the need for education. Behind the question of how far centralization or decentralization can wisely and efficiently be carried lies this fundamental problem of establishing the most effective working group or unit, on which Sir George lays such stress. The Acton Society Trust's study recognizes that the problems of decentralization are common to all large scale organizations, though appearing with different intensity in different industries. It is, however, the informal and uncodified relations which cause the trouble, rather than the officially defined limits of authority.

The main conclusion drawn from the present study is, in fact, that decentralization is primarily a problem of the adjustment of human relationships, and it is urged, in accordance with Sir George Schuster's view, that further research in other industries such as electricity or transport is desirable. Attention is directed, however, to two basic errors of thinking about the organization of the nationalized industries. The first is the belief that there is a 'best way' of carrying out any specific task and that science can discover it. The specialist is then conceived as the man who can work out what the 'best way' is. Accordingly, if the pattern of organization is such that the best specialist is put at its peak and consulted on everything, the undertaking will be run in the best possible manner. This assumption leads both to the construction of organizations of maximum size and to the imposition of uniform practices throughout those organizations. This view is based on a popular misconception of the natural sciences, and embodies just that habit of thought in the application of science against which Sir George gives so firm a warning. In the coal industry it is responsible for exceptional difficulties, partly because, while reorganization was urgently needed, experience in using specialists was considerably lacking, and there was also an acute shortage of specialists.

This is the feature of the study which is of most immediate interest here. Its discussion was indeed confined to the use of technical specialists in production, but this section of the study deserves careful examination by those concerned with the most effective use of the scientific worker or technologist in industry generally. Even if the difficulties are particularly acute in the coal industry for the reasons indicated, the nature of the relations between the operational or works manager and technical specialists of higher status, diffusion of authority resulting from the number of such specialists and from the number of stages in the management hierarchy, as well as the character and extent of the control and supervision exercised by higher management over lower management, all involve problems which require solution before high productivity can be expected. This brief discussion by the Acton Society Trust brings out very clearly the need for further thought as to the adequacy of the staff and line system in industry, on the definition of responsibility, and the need for much more forethought in the launching of large new projects involving new methods of operating. It is to be hoped that these problems of large-scale organization will not escape the notice of the British Institute of Management.

The second error of thinking relates to decentralization. It is assumed that an ideal compromise can be found which will make the best of both worlds, giving the plant or works manager freedom without sacrificing the advantages of scale. It may be, however, so the Acton Society Trust points out, that a compromise only provides the worst of both worlds, leaving the manager handicapped without achieving the technical advantages supposed to accrue from size. If that is so, a decision in favour of one extreme or the other would be necessary; but there may be room here also for further investigation. Such investigation must, however, keep clearly in mind the point made so strongly by Sir George Schuster regarding the importance of respecting human personality. That is no less important in considering changes in organization which affect the manager or the technologist than in considering conditions which affect workers on a lower level, and this latest study from the Acton Society Trust is implicitly as firm a protest against the purely materialistic or economic treatment of industrial problems as Prof. Mace's address on psychology and the laity or Sir George Schuster's Beckly Lecture. What is said about the importance of status in connexion with the colliery manager, and the recognition that the problem is at least as much one of education as of organization, sufficiently illustrate this, and have implications for other scientific and technical workers which suggest that professional bodies might well give careful consideration to these pamphlets.

CHEMISTRY OF THE EARTH

Geochemistry

By Dr. Kalervo Rankama and Prof. Th. G. Sahama. Pp. xvi+912. (Chicago: University of Chicago Press; London: Cambridge University Press, 1950.) 112*s*. 6*d*.

THE last important book in English on geochemistry, F. W. Clarke's "The Data of Geochemistry", first published in 1908, was also the earliest in this field of science which serves as intermediary between chemistry and geology. Since the third edition of Clarke appeared, major contributions have come from Vernadsky and Fersman in Russia, from Scandinavia, and especially from V. M. Goldschmidt of Oslo and Göttingen and his co-workers. Moreover, chemistry itself has made great new strides, especially, on the theoretical side, in the direction of radiochemistry, and on the practical side, in the application of spectrography and spectrometry to problems of analysis and separation. The earth is now to be understood in terms not merely of 96 elements, but also of 272 stable and 23 longest-lived unstable nuclides. The time is certainly ripe

for a treatment in English on the subject, and this comprehensive work by Rankama, of Helsinki and Chicago, and Sahama, of Helsinki, is one of first importance both for geologists and chemists.

The authors accept the threefold task of geochemistry as defined by Goldschmidt: to establish the abundance relationships of elements and nuclides in the earth; to account for the distribution of elements in the various terrestrial spheres; and to determine the laws governing the abundance and distribution of the elements. The book is divided into two parts, the first dealing with the general laws and regularities which determine the abundance and manner of occurrence of the elements, and the second considering the elements one by one.

In Part 1 the determination of abundance figures largely. On this subject it is difficult not to feel some misgivings about possible errors of sampling which might have a serious influence upon the conclusions reached. It might be asked, for example, whether 5,159 analyses, even when weighted according to superficial areas of rock-types, are sufficient to assess the composition of so large a subject as the lithosphere, particularly when the tendency for petrologists to collect specimens of only a few pounds or even ounces in weight is remembered. Similarly, it seems very doubtful whether the "average meteorite" has any fundamental significance. If any criticism of this excellent book is justified, it is that the formidable tables of abundance data give an impression of finality which more detailed investigation may perhaps prove to be misleading. A chapter on the geochemical structure of the earth deals chiefly with hypotheses originated by the geochemists Washington and Goldschmidt; the exclusion from this discussion of the numerous alternative views advocated by geophysicists (apart from a brief consideration of Kuhn and Rittmann's revolutionary ideas) is presumably deliberate and, for the purpose of the book, probably wise; the nature of the subcrustal layers and of the core remains a speculative subject and not open to direct geochemical observation. The spheres which are open to direct observation —the upper lithosphere, the hydrosphere, the atmosphere and the biosphere—receive very adequate treatment.

The elements which enter into the composition of the lithosphere are divided into oxyphile (the petrogenic elements of Washington) and sulphophile. A discussion of crystal chemistry follows, based upon the useful structural classification of the silicates advocated by Hugo Strunz, and this leads to a thoroughly modern account of the rock-forming minerals. Magma, not migma, is regarded as the basis for the crystallization of the important minerals, and the authors state their faith when they say ". . . notwithstanding the geological significance of the igneous-looking rocks formed by metasomatic infiltration and recrystallization processes . . . the phenomena connected with the crystallization of a rock melt are fundamentally important". This compromise has much to recommend it. The conception of a major endogenic cycle (rock-melt–igneous rocks–sediments–metamorphics–migmatites–rock melt) springs from it.

A minor cycle involving exogenic processes is also usefully recognized as underlying the formation of the sedimentary rocks. Here the geological reader will find unfamiliar terms such as resistates (clastic sediments), hydrolysates (clays, shales, bauxites), oxidates (iron–manganese ores), reduzates (sedimentary sulphides), precipitates (calcium and magnesium carbonates), evaporates (the evaporites of current mineral literature) and bioliths (organic sediments), the whole providing a system of sedimentary chemistry.

In Part 2 the individual elements are treated in accordance with a rigid plan under which abundance in rocks and meteorites is stated, occurrence in primary and secondary minerals in various spheres is considered, and a cycle of transition is deduced in most cases. Concentration into deposits of economic value is referred to here.

This book may well be hailed as a major contribution both to geology and chemistry, and it should have an important influence on workers in those fields where the two subjects converge.

K. C. Dunham

DEMOCRATIC PLANNING AND LIBERTY

Freedom, Power and Democratic Planning

By Karl Mannheim. Edited by Hans Gerth and Ernest K. Bramstedt. (International Library of Sociology and Social Reconstruction.) Pp. xxiv+384. (London: Routledge and Kegan Paul, Ltd., 1951.) 25*s*. net.

The Logic of Liberty

Reflections and Rejoinders. By Prof. Michael Polanyi. (International Library of Sociology and Social Reconstruction.) Pp. viii+206. (London: Routledge and Kegan Paul, Ltd., 1951.) 15*s*. net.

"FREEDOM, Power and Democratic Planning" concludes the studies of the theory and practice of sociology which Dr. K. Mannheim first expounded in "Ideology and Utopia" and continued in "Man and Society in an Age of Reconstruction". Like his earlier books, this posthumous volume is not always as clear in its treatment as might be desired, and here, far more than in the earlier books, the writing is marred by jargon which obstructs the argument and in the latter chapters even obscures the meaning. This is most conspicuous when he deals with religion and philosophy and the integration of the social order. While it is evident that Dr. Mannheim believed that society cannot be held together except by ethical, moral or religious forces, no more than in his "Diagnosis of Our Time" does he succeed in conveying to the reader any clear idea of what he understands by religion.

That is a serious defect in a book, which, addressing itself to the development of happier arrangements for achieving social reforms, establishes clearly the necessity for some spiritual or ethical basis such as the Western tradition and the acceptance of such values if a coherent society is to exist. It is the more unfortunate because for all the jargon, indifferent style and sometimes muddled thinking on certain topics, the book gives a picture of what is likely to happen to our society, and it is often both stimulating and suggestive. In spite of its faults it is an important book which directs attention to subjects which require careful thought and more objective study than they commonly receive.

Mannheim believed that freedom is impossible without the continuance of free institutions, but that the institutions which have served us in the past require modification if they are to be effective for the

preservation of freedom to-day. In what he called creative politics—or the creation or evolution and use of the appropriate institutions—planning has its place, although with Mannheim central planning was essential only in regard to certain basic issues of policy. Government and the community are not separate entities and he looked to the organized group to give to the individual the opportunity to express his personality, while the activities of the groups are broadly co-ordinated in the interests of the community as a whole by the central authority.

For this to be possible, there must be a degree of social unity such as was achieved with our existing institutions in time of war. In time of peace this involves, first, re-shaping institutions so that power may be brought under democratic control; next Prof. Mannheim postulated the fostering by more adequate social education of democratic behaviour and personality to inculcate co-operation and tolerance; and third, the re-definition of values and re-discovery of an ethic generally shared to be found in what he describes as a 'dynamic religion'. On the defects of existing institutions Mannheim wrote shrewdly, and his criticisms and observations on such matters as the selection and training of leaders, the dangers of levelling down, the problem of loyalty, the position and functions of the Civil Service, the Press or broadcasting, and functions and relations of organized groups to society as a whole are often illuminating as well as wise. He understood, too, the limits as well as the dangers of some of the new techniques, and while he recognized their value he insisted that by themselves they offer no solution to the problem of power.

Some of his comments here recall Mr. Charles Morgan's recent emphasis on the dangers of the control or changing of human personality to which such techniques now expose us, but Mannheim is no more constructive than Morgan and some of his proposals are unconvincing. He appears to be overconfident as to the possibility of transforming men and institutions, and leaves his readers at least in some doubt as to whether his restraints and moderating influences will suffice.

For this there are probably two reasons. First, in respect of the re-shaping of institutions, he does not really feel the problems of the conflict that inevitably accompanies the disturbance of privilege and traditional patterns. His discussion rarely goes as deep as that of Sir Ernest Barker in his "Reflections on Government", and on the institutional side there is little to be found here that was not implicit or explicit in that book of nine years earlier.

The second reason is Mannheim's failure to convey any clear idea of what he understands by a dynamic religion. If some ethic or religion is to supply a cement which will hold the fabric of society together and give it unity, that ethic or religion must be expressed clearly enough to fire the imagination of men and women and claim not merely intellectual assent but also something of the moral fervour or passion that has marked all the great cultural or religious revivals of the past. For that the sincerity of this book, the clarity of its diagnosis, are insufficient. When he wrote, Mannheim himself appears to have been still groping for the faith, for the spiritual basis which he recognized as essential if the atrophy of Western civilization is to be arrested and men are to recapture that sense of purpose, that vision of greatness, required for the re-shaping of its institutions.

"New Ideas," wrote Mannheim, "always have originated in small groups with enduring personal contacts. . . . It is still the dissenting small group that favours inspired adventures of the mind and intellectual enthusiasm." This passage, in which he urged that such intellectual oases are the natural and only protection of society to-day from the deadening uniformity which propaganda tends to impose, provides a natural link with those reflexions and rejoinders on the theme of liberty which Polanyi has collected under the title "The Logic of Liberty". The essays, indeed, are not new, but through them runs the same theme of the vulnerability of freedom, the necessity for a fresh defence in this troubled period of history and for a re-assertion of ideals which we have allowed to become discredited.

Polanyi is concerned primarily with the defence of science, but this he insists is part of the defence of our civilization. The forces undermining the position of science are a detachment of those assailing our whole civilization, and when he claims for science the respect due to it as a cultural and moral value he is repudiating as firmly as Mannheim the adequacy of a purely materialistic basis for civilization. This, far more than his re-assertion of the incompatibility of planning or directed research with the freedom which is the very essence of science as a vital activity, the search for truth and an example of the good life, is the keynote of the book, and it would be unfortunate if his shrewd attack on planning and exposition of the limitations in any way obscured this wholehearted challenge to the materialistic thesis.

Throughout the book, Polanyi emphasizes that liberty is conditioned by society and that the freedom in which science develops is a form of intellectual liberty, while economic liberty he regards as a kind of technique. Polanyi is easiest to follow in this first part of the book, where he deals with the example of science and is here even more suggestive than Mannheim as to the way in which small groups or professional institutions can contribute to the building up and safeguarding of a free society. His exposition of an engineering or physical approach to economics is more difficult for a layman to follow, and its value appears to be less constructive. He is more effective in disposing of the pretensions of central planning than in concrete suggestions as to how liberty is to be defended.

The great value of these two books is that they do not merely defend freedom: they assume the offensive and attack the ideas that lie at the basis of those forces or institutions which to-day threaten the free society. Both writers have the courage of their conviction that a free society is a true end in itself—a body of men who respect truth, desire justice and love their fellows—and that accordingly it may rightly demand the services of its members in upholding its institutions; and, as already noted, where Polanyi deals specifically with the freedom of science itself, it is as a part of the larger problem. Scientific beliefs, in his view, are part of the beliefs cultivated in a free society and accepted by its members.

Polanyi's argument that the scientific worker should not limit himself to the defence of freedom of science as such but should play his part in the defence of the free society in which alone science can fully function, carries, however, the corollary that there should be a much clearer understanding in the community as a whole of what science really is, and how it works to widen the understanding of Nature

necessary to all men. That academic freedom can claim to be an efficient form of organization for discovery in all fields of systematic study controlled by a tradition of intellectual discipline has its implications outside the strictly scientific field and especially in relation to what Polanyi describes as the achievement of spontaneous order. So, too, inasmuch as freedom of science, like freedom of worship or freedom of thought in general, can be described as a public institution by which society opens to its members the opportunity for serving aims that are purposes in themselves, the way in which the mutual co-ordination of scientific activities is achieved within the field of science itself by consultation, competition and persuasion bears closely on the evolution of the new forms of organization and means of social adjustment which Mannheim sought.

There is much, indeed, in both these books to stimulate the thinking among professional men which is required to safeguard freedom to-day. They represent one group which has an indispensable part to play, not the less because of the inherent tendency of all professional bodies or associations to become conservative or ossified. They, of all men, need to keep in mind the warning from the sixteenth century: "There never was anything by the wit of men so well devised, or so sure established, which in continuance of time hath not been corrupted". R. Brightman

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UNIVERSITY OF MANCHESTER, 1851–1951

Portrait of a University, 1851–1951

To Commemorate the Centenary of Manchester University. By Prof. H. B. Charlton. Pp. x+185+23 plates. (Manchester: Manchester University Press, 1951.) 15*s*. net.

ONE reviewer of this book has complained because Prof. H. B. Charlton did not write a full, systematic history of the University of Manchester. Evidently, he did not know Prof. Charlton—the last person to try to produce such a thing on any occasion. On the occasion of a centenary it would have been wrong to try. Instead, he has done something more difficult, which he alone could do, and which will be far more useful to future historians of Manchester and other universities. He has done precisely what the title of the book claims. One hundred years is not long in the life of an institution, so that it is possible to depict it as a unity during that time. But one hundred years, in these migratory times, is almost immeasurably beyond the span of one man's memory. Prof. Charlton has an academic memory far longer than most, for he has been on the staff of the University of Manchester for very nearly forty years. Not only has he seen and taken part in all that has happened since the First World War, but also he knew the leading men of the previous period when Manchester was emerging as a complete university. (In parenthesis: though Owens College ceased to exist legally in 1904, its name still came easily to the ordinary man in the Manchester street thirty years later, whereas the name 'University' meant little and the title 'Victoria' nothing.) Charlton is fortunate, too, in earlier historians. Edward Fiddes, for long a colleague of his, whose actual acquaintance with the University went back to 1890, wrote its history up to 1914. There is also a valuable account of Owens College up to 1886 by Joseph Thompson.

The main theme of this book is: What were the aims of the founders and initiators, and in what manner have they been fulfilled? Prof. Charlton distinguishes four stages in the process. The early stage was that of the old Owens College in its cramped quarters in Quay Street, with its sixty or seventy students and its half-dozen professors, each teaching two if not three subjects. (To be exact, on the photograph opposite p. 16 there are eight professors; they are less bewhiskered and bearded than one would expect, perhaps because they were rather young.) The next stage was the move to the new site in Oxford Road, soon discovered to be too small, the incorporation of the Medical School, older than Owens, and the foundation of a federal university, with Liverpool and Leeds as partners. In the third stage came the attainment of full university status; and then the modern period, with, now, nearly six thousand students, including those in medicine and technology, and a teaching staff of more than eight hundred. Incidentally, the book is well equipped with statistical data, plans and illustrations.

In claiming that the aims of the founder have been and are being fulfilled, Prof. Charlton has to make a very interesting qualification. Robert Owens wrote in his will that the college was to be for the education of "young persons of male sex", and we can only guess what he would have thought of the thousand or more young persons of female sex now studying there. In 1845 when he died there could as yet be no question of higher education for women, since there was next to nothing of secondary education for them; indeed, there was not too much for their brothers. A quarter of a century later, conditions had changed, the question did arise and Parliamentary sanction was obtained to set aside the restriction. However, Manchester acted on it extremely cautiously. If there was too much delay in admitting women, particularly into the Medical School, there has been compensation since. Assuming that Owens was hostile to the higher education of women (we do not know that he was), he would have been instantly converted on being introduced to the first lady who occupied a chair and the two who have followed her. Edward Fiddes's account of this whole controversy is reprinted in an appendix.

Robert Owens, and his friends and successors who took the first steps, wished to foster higher education, and in doing so to serve the special interests of Manchester and its neighbourhood. Young people need to have their minds enlarged and elevated; they also need to earn a living, and can do that best by pursuing effectively the normal activities of the community they live in. On the narrowest interpretation of technical efficiency, the practitioner is none the worse if he grasps the principles underlying his practice or even knows something about other things also.

Prof. Charlton quotes a number of statements of university aims and methods from earlier members of Owens College, from Ward, Roscoe, Schuster and Tout; he also does a valuable service in printing in full Samuel Alexander's essay, written in 1931, which begins: "I should describe a university as an association or corporation of scholars and teachers engaged in acquiring, communicating, or advancing knowledge, pursuing in a liberal spirit the various sciences which are a preparation for the professions or higher occupations of life. The omission of any part of this description would convey a false impression of what a university is. It does not exist only for acquiring or communicating the higher branches of

knowledge, but for extending them as well; and it does not only pursue the sciences for their own sake, but, so far as the larger part of its members are concerned, pursues them in preparation for the professions. I had almost said that the purpose of a university was to prepare for the professions, and I should be ready to defend this, provided that the qualifying words, 'in a liberal spirit', are not merely not omitted but emphasized." It is tempting to go on quoting from one who did so much within the University of Manchester and outside to demonstrate what is meant by 'a liberal spirit'. A. D. RITCHIE

LAW OF COPYRIGHT AND INDUSTRIAL DESIGNS

Copyright and Industrial Designs

By A. D. Russell-Clarke. Pp. xv+262. (London: Sweet and Maxwell, Ltd., 1951.) 37*s*. 6*d*. net.

THIS book embodies all aspects of copyright, whether literary, dramatic, musical or artistic, together with copyright in industrial designs. It is the first of its kind to include all these branches of copyright. The author is to be congratulated upon the lucidity and practical manner with which he deals with the difficult questions in the field covered by the Copyright Act of 1911 and the Registered Designs Act, 1949. Prior to the coming into operation of the Designs Act, 1949, copyright in industrial designs was largely associated with the patent law rather than the copyright law. In 1947 the departmental committee, set up under the chairmanship of Sir Kenneth Swan to inquire into the working of the Patent and Designs Acts, recommended a number of changes of the law relating to designs. As a result of these changes, it has been made clearer that the law of copyright in industrial designs has a closer affinity to the law of literary copyright than to the law of patents.

The first part of the book is devoted to a detailed examination of the Copyright Act of 1911, in relation to literary, dramatic, musical and artistic work. The author points out the remedies available to copyright owners, and two chapters are usefully devoted to questions of licences and publishing and other agreements. At a time when publishers appear to be inclined to remunerate authors of technical books at the lowest possible rates, the suggestions contained in this part of the book are likely to be of some help. A chapter is devoted to miscellaneous matters such as the term of copyright, University Copyright and Crown Copyright.

Part 3 of the book concerns the Registered Designs Act, 1949, which came into force in January 1950. So far there have been very few reported cases under this Act which have anything at all to do with designs. The author deals with the nature of the design, its publication, the available remedies for its infringement and the procedure for applying for registration at the Patent Office whereby copyright may be obtained for a period of up to fifteen years. Part 4 deals with cases of overlapping which occur between the Copyright Act and the Designs Act.

The book is well indexed, and the fact that neither of the two Acts is set out in full has assisted in keeping the price and the size reasonable. It is certainly a book which should prove of great assistance not only to practitioners, but also to members of the technical staff of firms, designers and authors. R. G. LLOYD

SOCIETY UNDER THE MICROSCOPE

Social Surveys and Social Action

By Mark Abrams. (Contemporary Science Books.) Pp. v+153. (London: William Heinemann, Ltd., 1951.) 8*s*. 6*d*. net.

IN this little book Mr. Mark Abrams starts with the emergence of Booth and Rowntree, the pioneers, and shows what has developed out of their pioneering experiments. He is concerned with the social survey, not as an instrument of fundamental research, but as a form of investigation used in the twentieth century to assist in the identification and quantitative analysis of social problems which call for social action. He traces the development from poverty studies to a wide range of inquiries directed to matters in which questions can be more exactly related to the needs of social policy—nutrition, old people and town planning—and he explains how the Second World War led the British Government to start its own survey department and how companies specializing in survey work arose and have been increasingly employed to make investigations on behalf of public authorities and private agencies. These are the direct descendants of the pioneers. In addition, there are the 'borrowers'—market research and public opinion polls. Finally, Mr. Abrams discusses the role of the social survey in the Welfare State, and has some interesting things to say about the way in which surveys might help to discover how to make public communications intelligible to the masses. This is a worthy aim provided one does not forget the complementary process of making the masses sufficiently intelligent to understand the communications.

Thus the reader is given a genealogy which will be helpful to the novice; but that is not enough to satisfy the serious student, and the book as a whole is disappointing, although the subject is fascinating and the author an acknowledged expert. With such limited space at his disposal, the author could achieve success only by selecting a narrowly defined theme and sticking to it. He has, by a narrow margin, failed to do this. A chapter is devoted to the historical antecedents of the pioneers, and it treats familiar material in a rather crude manner. Another chapter gives an account of social surveys in the United States and is too sketchy to have much value. The author would have done better to fill out his descriptive picture of survey organizations in Great Britain at the present time. A better balance would have been obtained if he had devoted less space to Mass Observation and had found room to mention such organizations as the British Institute of Public Opinion and the National Institute of Economic and Social Research.

If we assume that Mr. Abrams's theme is the social survey as an application of scientific method to the handling of practical social problems, then we should expect to be taken rather further on three points: first, the grounds for claiming that the survey method can be truly scientific; secondly, the respective roles of routine official collections of data and of *ad hoc* surveys; and thirdly, the extent to which the results of social surveys can, and do, point unequivocally to particular forms of social action and the point at which political judgment must enter. All these points are mentioned; but the argument is not sufficiently firmly pulled together to leave a clear impression on the mind of the reader.

T. H. MARSHALL

The Infinite in Giordano Bruno

By Sidney Greenberg. With a translation of his Dialogue, Concerning the Cause Principle, and One. Pp. ix+203. (New York: King's Crown Press; London: Oxford University Press, 1950.) 20*s*. net.

THIS erudite contribution to our knowledge of the works of Bruno the Nolan is one of the latest examples of the value of the policy adopted by the King's Crown Press in making specialist studies available to scholars at a very reasonable cost. The volume divides naturally into two—the place of the infinite in Giordano's system, and a translation of the "De la Causa" into English. (Incidentally, there seems to be a comma missing from the title-page, which makes the full, and very noble, phraseology read rather oddly.)

Broadly, these massive writings are, as the author states, the outcome of Bruno's striving to "comprehend the Universe". At the same time, allowing for the tensions inseparable from the onset of humanist philosophies, it is not surprising that much heat was generated *en route*, and that only comparatively recently has this one-time Dominican monk come into his own. We are beginning to realize more explicitly nowadays that the *ordo essendi* is seldom the *ordo cognoscendi*. Meanwhile, Dr. S. Greenberg's reference to Gilson (p. 15) gains added weight if the original setting is consulted. For there, 'good' is contrasted with 'Being': a limitation is implicit in the former, but not in the latter, which is why the Greek 'infinity' was always coupled with imperfection.

English-speaking students will be grateful for being enabled to follow Bruno's great work of 1584 the more readily, and thus to appreciate some of the qualities of that tempestuous intellect.

F. I. G. Rawlins

Die botanische Buchillustration

Ihre Geschichte und Bibliographie. Von Claus Nissen. Band 1: Geschichte, Lieferung 1. Pp. vii+80. Band 2: Bibliographie, Lieferung 1. Pp. vii+80. (Stuttgart: Hiersemann Verlagsgesellschaft m.b.H., 1951.) n.p.

IN the drawing and painting of plants—especially of flowers—art and science meet, sometimes overlap and occasionally combine. The diversity and beauty of form and colour to be found in the plant kingdom attract the artist, while the botanist often finds accurate representation in black-and-white or in colour more valuable as a record of his studies than verbal description. The best botanical artists have combined in their work the feeling of beauty with the accuracy of detail demanded by the man of science. Lately, there has been an increased interest in the history of botanical illustration, an interest apparently not confined to Great Britain.

It is impossible fully to judge the value of C. Nissen's work from Part 1 of Volume 1 and Part 1 of Volume 2. The first volume is to deal with the history of the subject. Its first part contains a brief introduction dealing with some aspects of technique and consideration of botanical illustration in ancient times, the Middle Ages, the period of early printing, the Renaissance, and the Baroque Period (in part). The second volume is, in the first part, strictly bibliographical (authors *A* to *He*). Since there is at present no scheme of contents, it would be unfair to criticize the scope and arrangement of the work from the two parts. There appear, however, to be a number of surprising omissions. Thus, under William Curtis one would expect to find some information about the *Botanical Magazine*. Again, under H. N. Dixon there is no mention of the third (1924) edition of "The Student's Handbook of British Mosses".

The many references provided in both parts should be of considerable interest and use to all who study the history of botany. It is to be hoped that a good index will be provided.

W. B. Turrill

Fourier Methods

By Prof. Philip Franklin. Pp. x+289. (London: McGraw-Hill Publishing Co., Ltd., 1949.) 34*s*.

PROF. PHILIP FRANKLIN surveys a wide field, interpreting the phrase of his title as covering any method which analyses or synthesizes a function by means of periodic components. He is writing for the technologist, and illustrates plentifully from the field of mathematical physics, but is content to quote the fundamental theorems of pure mathematics which he requires. References to the mathematical theory and for further reading are given.

The first chapter deals with the elements of the theory of complex numbers, with applications to impedances. The second chapter describes the Fourier series and the Fourier integral, including a summary of twelve-ordinate harmonic analysis, the third studies partial differential equations, and the fourth boundary values problems, particularly those arising in heat conduction and in transmission lines. In the last chapter the Laplace transform is briefly described and applied to problems of electric circuits and transmission lines. There is a full supply of worked examples, and an excellent collection of elementary exercises for the reader, with answers.

The treatment is clear, but since so much is dealt with in a comparatively small book, it is never profound. The book would thus serve to introduce the young student to a wide field of knowledge, without requiring anything more than a grasp of elementary calculus as a prerequisite. But it is only an introduction, and the suggestions for further reading should be taken seriously.

The Life of a University

By Basil Cottle and J. W. Sherborne. (Published for the University of Bristol.) Pp. vi+116 (50 plates). (Bristol: J. W. Arrowsmith, Ltd., 1951.) Paper, 6*s*. net; cloth, 10*s*. 6*d*. net.

THIS brochure is a well-written sketch of the growth and organization of the University of Bristol and some institutions connected with the University. There are some fine illustrations; but the title of the book is not happily chosen. Rather less than half of the book is occupied by a short history of the University, the remainder sketching the organization and present activities. It is thus less an account of the life of a university than of its growth and structure, being purely descriptive. Although entirely different in form, it covers essentially the same ground as the pamphlet "An Introduction to a University" put out by the University of Birmingham, but is scarcely so well designed as the latter pamphlet to guide those who are facing a decision as to whether to enter a university at all. The "Life of a University" appears to be designed, on the contrary, for past or present members of the University of Bristol itself, whether students or staff, and to them it may be further commended for the excellence of its general production.

ARTIFICIAL ACCELERATION OF ATOMIC PARTICLES*

By Prof. O. R. FRISCH, O.B.E., F.R.S.
Cavendish Laboratory, Cambridge

THE progress of nuclear physics in the past two decades has depended greatly on the use of machines for producing high-energy particles; these fast particles are used for bombarding atomic nuclei with the aim of producing nuclear transformations. Though the first machines were built nearly twenty years ago, much still remains to be known about the atom. It must be remembered that we know to-day about nine hundred different kinds of atomic nuclei; only three hundred of them are found in Nature, while the remainder have to be prepared artificially, using either high-energy particles or neutrons coming from a nuclear pile. Furthermore, each of these nuclei is a complicated structure, with features many of which are still not understood. Finally, quite new phenomena have been recently discovered, such as the artificial creation of mesons in high-energy nuclear collisions. These mesons, previously found only in the cosmic radiation, can now be studied much more closely, and their study is thought to bear closely on the riddle of the 'nuclear forces', the forces whereby the particles in an atomic nucleus are held together.

Considering the use of fast particles for splitting atoms, it must be remembered that nearly the whole weight of an atom is contained in its nucleus, in size a minute fraction of the atom; all the rest is a tenuous cloud of electrons moving around the nucleus at great speed. Removal of a few of these electrons does not constitute atom splitting; it happens in many chemical reactions, in flames and even in friction, as when glass or ebonite becomes electrified by rubbing. The arrangement and motion of those electrons follow the laws of quantum theory and are, on the whole, so well understood that it is possible, in principle, to compute beforehand the physical and chemical properties of a new chemical compound, though the calculations are usually hopelessly complicated.

Of the structure of atomic nuclei far less is known. Their sizes and their electric and magnetic properties can be measured, but give only indirect evidence of internal structure. In order to learn about the parts of a nucleus and how they are held together, we must break up the nucleus, and the most suitable tool is another nucleus, preferably a smaller one. Such a particle is fired with great speed at the nucleus to be broken up. Of course, we cannot take aim: we have to fire a great many shots at random and hope that some will score. Passing through any given atom, such a nuclear bullet has only a minute chance—perhaps one in a hundred million—of hitting its nucleus, but it can pass through many thousand atoms in succession. Thin aluminium foil—the so-called 'silver paper'—contains about a hundred thousand layers of atoms; on passing through this foil, a nuclear bullet has about one chance in a thousand of hitting an aluminium nucleus. By using many millions of bullets a respectable number of hits can be achieved without any marksmanship whatever.

There are two reasons why bullets of high energy, that is, very fast ones, have to be used: the bullet must be able to break through the electronic shells of many thousand atoms; and it must be able to overcome the electric repulsion which it experiences on approaching another nucleus, caused by the positive electric charge which they both carry. This repulsive force gets very large; for example, an alpha-particle—that is, a helium nucleus—almost touching a uranium nucleus gets pushed away with a force of nearly a hundredweight. Such force represents a kind of barrier through which the bullet has to break before it can touch the nucleus, and the size of this barrier corresponds to the electric potential at the surface of the nucleus. This potential can be easily calculated, from the known size and electric charge of the nucleus. For example, the potentials on the surface of nuclei of carbon, copper and uranium are 2·6, 7 and 15 million volts respectively. Thus, nuclear bullets have to be accelerated with potentials of the order of several million volts in order to enable them to enter an average atomic nucleus.

Potentials of several million volts are not easy to produce or to handle, but generators for potentials up to about four million volts have been built and are being used by nuclear physicists. They usually follow a design by Van de Graaff and employ a fast-moving belt to carry electric charge to the high-voltage electrode, much as a belt-conveyor carries gravel or coal to a higher level. Ions are produced by an electric discharge and are then driven through the accelerating tube to a target at ground potential containing the nuclei to be bombarded. To delay the onset of sparking, the whole arrangement is usually placed in a boiler-like container which can be filled with compressed air or nitrogen. Because of their limited voltage, these electrostatic generators are useful for attacking light nuclei only—that is, elements in the Periodical Table up to, say, calcium. On the other hand, they are very suitable for precision work since they can be stabilized so that the voltage varies by less than one part in ten thousand; this is important because some of the phenomena caused by nuclear bombardment depend extremely sharply on the bombarding energy, that is, on the accelerating voltage.

For the acceleration of particles to much higher energies, the principle of multiple acceleration has been developed, whereby a comparatively small voltage is applied to the same particle a number of times. The first multiple accelerator was built by E. O. Lawrence and D. H. Sloan in 1930. It consisted of a number of metal tubes, all lined up in an evacuated container, and connected alternately to the terminals of a high-frequency generator of alternating electric potential. The length of the tubes was chosen such that a particle which had been accelerated on entering a tube would again be accelerated on leaving it, the potential having changed sign in the meantime. In this way they succeeded in accelerating mercury ions to energies of 90,000 volts, merely to show that the method would work, and well knowing that such mercury ions are useless for nuclear disintegration work. The chief difficulty of extending that method to lighter particles and higher energies lies in the great

* Substance of a Friday Evening Discourse at the Royal Institution, delivered on May 11.

speeds involved. For example, a proton, that is, a hydrogen nucleus, which has been accelerated by a potential of five million volts—or by an equivalent repeated application of smaller voltages—will have a speed of about 17,000 miles per second. Even if we allow that its average speed during acceleration is somewhat lower, it will travel fifty feet in one-millionth of a second. During this short time the electric potential must change a number of times if we are to get any real benefit from the multiple acceleration principle. In other words, we have to apply an electric potential which changes many million times in a second, as in a short-wave radio transmitter, and such transmitters, with the required power, did not exist in 1930.

In order to accelerate protons to several million volts, Lawrence had to use a much longer path, of many hundred feet, and in order that the apparatus should be of manageable size he made the particles follow a circular path. The principle can be illustrated by a crude model in which there is a horizontal circular rail, pivoted so that it can be slightly tilted one way or the other, and by suitable manipulation a steel ball can be made to go round faster and faster until it jumps from the rail on account of its centrifugal force. To make a charged particle follow a circular path, a magnet is used. If a particle moves at right angles to the magnetic lines of force it will be pushed sideways at right angles to the lines and to its direction of motion; and, if the field is uniform, it will describe a circle in a plane perpendicular to the lines of force. The diameter of the circle is inversely proportional to the strength of the field and proportional to the speed of the particle; this latter fact is of decisive importance because it means that a particle always takes the same time for one circuit, whether its speed be high or low. Although at extremely high speeds, approaching that of light, this is no longer true, when Lawrence and Livingston built their first 'multiple magnetic resonance accelerator', or cyclotron as it was nicknamed, the constant time for one circuit greatly eased their task of design.

To produce economically the strong and extended magnetic field which is needed, one employs an electromagnet consisting of a suitably shaped core of soft steel surrounded by coils through which an electric current is passed. Its shape can be derived from two horseshoe magnets by appropriate deformation. Between the two horizontal circular pole-faces, where a fairly uniform magnetic field exists, the tank is inserted and thoroughly evacuated by continuously operating pumps so that the protons to be accelerated can move freely. The electric accelerating field is usually made between two hollow electrodes called 'dees' (because they are shaped like a D), which are connected to a short-wave generator with the power of a medium-sized radio transmitter and working at a frequency adjusted accurately so that the voltage changes sign in step with the protons going round. The protons, which are produced near the centre by passing fast electrons through hydrogen gas, are then pushed back and forth by the electric field between the 'dees', and at the same time their path is bent by the magnetic field; thus each proton describes a path which looks like a spiral but is more nearly a succession of larger and larger semi-circles. The acceleration ends when the proton gets near the edge of the magnet; hence bigger magnets are needed to make faster protons, since the intensity of the magnetic field is limited by saturation of the steel. The fast protons can be utilized either by inserting a target into the tank so as to intercept the protons at the desired speed, or else an electrically charged deflexion-plate can be employed to persuade a fraction of the protons to leave the magnet in a tangential beam so that experiments can be more conveniently done away from the magnet.

The particles most usually accelerated by a cyclotron are protons and deuterons, the nuclei of ordinary and heavy hydrogen, respectively. Although the latter forms a rare admixture—about one part in five thousand—of natural hydrogen, it is fairly easily separated and is nowadays marketed by the ton for nuclear fission piles. A cyclotron accelerating deuterons uses a few ounces a year.

A deuteron is composed of a proton and a neutron, and if a beam of deuterons impinges on a target made of a light element, it often happens that the proton sticks to a nucleus while the neutron goes on. The target thus becomes a source of neutrons, and by choosing the target element and varying the speed of the deuterons, the speed of the resulting neutrons can be adjusted within fairly wide limits. This feature is still valuable, although for sheer numbers produced a fission pile is now a much superior neutron source.

The impact of the deuteron may also result in the emission, not of a neutron, but of a proton, an alpha-particle (a fast helium nucleus) or some other nucleus. The distribution in energy and angle of those particles emitted provides valuable clues to the structure of nuclei and is being intensively studied. Furthermore, the nucleus left behind may in many cases be one of those which are not found in Nature, because they are intrinsically unstable, that is, radioactive. Indeed, one of the most important applications of cyclotrons is the production of artificial radioactive substances, for, though many of them can be made more cheaply by neutron bombardment in a fission pile, others still need to be made in a cyclotron.

The construction of cyclotrons for energies substantially higher than, say, ten million volts is made difficult by the fact that the mass of the particles increases with increasing energy, in accordance with the laws of relativity theory, and that the time taken for one whole turn increases in the same proportion. A proton of ten million volts energy is one per cent heavier than a slow proton and hence takes one per cent longer for each turn; at this stage a proton can still make a number of turns before it gets out of step. But at a hundred million volts the difference is ten per cent, and also many more turns are needed to achieve acceleration to such an energy. This problem is aggravated by the need of shaping the pole-faces so that the magnetic field decreases slightly from the centre to the edge. Such a decrease causes the lines of force to bend like the staves of a barrel, and this in turn has a beneficial 'focusing' effect on the particles: it deflects them back to the mid-plane between the pole-faces if, by starting obliquely or by being slightly deflected in flight, they have started to move towards one of the pole-faces. Without this focusing, practically all the particles would strike one or the other pole-face long before they are fully accelerated.

When Lawrence, shortly before the Second World War, started to build a giant cyclotron with a magnet weighing 4,000 tons and pole-pieces 15 ft. in diameter, many people doubted that he would be able to accelerate protons up to the edge of that magnet. Yet it was done, by using a high-frequency generator

with variable frequency, containing a tuning condenser driven by an electric motor, so that the frequency goes up and down a thousand times a second. Most of the time the frequency is wrong; protons may start, but get out of step after a few turns. However, once in each cycle, the frequency decreases through its 'correct' value, and then a swarm of protons starts spiralling outwards. As they get faster they gradually take longer for each turn, but the electric waves, too, get slower, so the protons can remain in step. No careful adjustment is needed: if the protons are accelerated too rapidly, they begin to get out of step, and that automatically reduces their acceleration so that the tuning condenser can catch up with them. This self-synchronizing feature is extremely valuable, and indeed this so-called synchro-cyclotron (also termed frequency-modulated cyclotron) is much easier to operate than an ordinary one, where the frequency has to be very carefully adjusted. The biggest synchro-cyclotron at present in operation is in Chicago and generates protons of nearly 500 million volts.

Not only fast nuclei but also fast electrons are of interest to the nuclear physicist. Being negatively charged, they are not repelled by nuclei; on the other hand, they are found to have very little effect on them. But fast electrons can be used for making hard X-rays, which are very suitable for putting a well-defined amount of energy into a nucleus.

Electrons are much lighter than protons—about 1,800 times lighter—and can thus be easily accelerated to speeds close to that of light. At three million volts, an electron has 99 per cent of the speed of light. Any further voltage produces scarcely any increase of speed, but merely an increase of mass: the electrons are 'aggravated' rather than accelerated—though the latter term is still generally used. This nearly constant speed means that electrons can be accelerated on a fixed circle by an electric field of fixed frequency, but the magnetic field which bends their path into a circle must be made to increase rapidly with time, to keep them to the same circle in spite of their growing energy. Again, the system turns out to be self-synchronizing, and it has become known as the synchrotron. It was invented about 1945 by Weksler in the U.S.S.R. and independently by E. McMillan in the United States, who also built the first big one, for about 300 million volts, after a small one had been built and operated in Great Britain.

The synchrotron is capable of reaching higher energies than the earlier and somewhat similar betatron; but with both machines the radiation of electromagnetic waves from the circulating electrons rises very rapidly with increasing energy and sets a practicable limit somewhere about 500 million volts. This difficulty is avoided if the electrons are accelerated in a straight line; such an arrangement harks back to Lawrence's first multiple linear accelerator, but, in the meantime, the development of radar has made possible the generation of much higher frequencies at much greater power.

A modern linear accelerator for electrons (a proton accelerator has been built, but seems to have no great advantages) consists of a long evacuated tube through which electrons are pushed along by electromagnetic waves, much as a surf-rider is propelled by ocean waves. In order to adjust the speed of the waves to the correct value, the interior of the tube is 'corrugated' by the insertion of numerous metal irises, accurately machined and spaced. Several pilot models have been built and operated in Great Britain during the past few years, and machines for medical use are now under construction. A large linear accelerator, designed for producing electrons of 1,000 million volts, is partly completed in Stanford, California.

The chief object of these extreme-energy machines is the production and study of mesons, particles intermediate in mass between the electron and the proton. Yukawa pointed out in 1935 that the short-range forces, known to exist between the parts of a nucleus, suggested the existence of such intermediate particles, about two hundred times heavier than electrons. This theory, now widely accepted, does not suggest that mesons are actually present in nuclei. Theoreticians, if pressed on that point, like to say that the particles in a nucleus are held together by the exchange of virtual mesons. It is difficult to picture a virtual meson; perhaps I may suggest that the relation between a real and a virtual meson is the same as between a £5 note and an I.O.U. Like the latter, a virtual meson has a limited circulation; it can be exchanged only between particles in the same nucleus, which are, so to speak, held together by their mutual debts. If a nucleus is hit by a particle from outside, bringing a lot of energy with it, this sudden affluence may enable one or more of the particles in the nucleus to settle their debts and to escape. If the energy is big enough—some 200–300 million volts—then a real meson may appear. Under bombardment at such energies, mesons are indeed observed, usually through the characteristic tracks they form in special photographic emulsions; these tracks are intermediate between the fairly straight tracks formed by protons and the thin and rather curly ones formed by electrons.

It should be stressed that the theory of mesons is much more definite and clear-cut than my general description may suggest. It makes definite predictions relating the known properties of nuclei to the as yet unknown properties of mesons. To test those predictions, we have to study the velocities with which mesons emerge from a nucleus struck, say, by a fast proton, the effect of proton speed on the speed and number of mesons created, the interaction of mesons with matter through which they pass, and so on. We know already that there are at least three kinds of mesons with different mass, each of them unstable and prone to transform itself within a small fraction of a second into a lighter meson or an electron, or even into two photons (quanta of electromagnetic radiation). Thus there is a whole new world to be explored, a world of ghostly, fast-moving, short-lived particles, at the very fringe of our everyday world and yet perhaps essential for our understanding of why ordinary matter is what it is.

PRESERVATION OF BIOLOGICAL MATERIALS BY FREEZE-DRYING

DURING June 29–30 the Institute of Biology held a symposium on "Freezing and Drying" in the rooms of the Royal Institution. The first session, with Dr. R. I. N. Greaves in the chair, was devoted to consideration of the industrial applications of freeze-drying and its use in the preservation of food. E. W. Flosdorf surveyed methods current in the United States for the preparation of materials

for large-scale drying, including pre-freezing and freezing *in situ*, and for the supplying of heat to the drying product by circulating hot water, direct electrical heating or infra-red radiation. A variety of systems for vacuum maintenance are in use, including oil pumps in conjunction with mechanically refrigerated condensers or direct pumping of the water vapour with multi-stage steam ejector pumps. Materials now available commercially in frozen-dried state in the Western hemisphere include human blood products such as immune serum globulins, enzymes, vitamins, antitoxins, antibiotics, hormones, veterinary vaccines, laboratory biological reagents such as complement, and food products, coffee, pineapple juice, orange juice and raw ground beef.

Application of the method to the production of antibiotics was discussed by J. H. Singer. The problem of maintenance of sterility has been overcome by fitting the trays of antibiotic (either in vials, or in bulk) with metal lids which can be raised hydraulically within the desiccator chamber by outside control. Bulk-drying procedures have been adopted for streptomycin calcium chloride and dihydrostreptomycin sulphate. Sterility is maintained by filling sterile stainless-steel trays *in situ* with a dispensing device delivering the correct quantity of sterile solution.

The high cost of production will almost certainly prevent the commercial utilization of freeze-drying for food preservation, but R. Gane showed that such varied materials as sliced apple, fruit juices, liquid egg, meat and fish can be dried without much difficulty. Reconstitution of meat and fish tends to be difficult, however, if the pieces are more than 1 cm. thick. Vegetables, such as peas, with an impermeable skin cannot be frozen by evaporation and pre-freezing, and grinding is essential. The immediate value of freeze-drying applied to food lies in its preparation for biochemical analysis. The last paper in this session, by L. G. Beckett and A. S. D. Barrett, was a consideration of physical aspects of the design of freeze-drying equipment with reference especially to vacuum technology.

Papers given in the second session, with Sir Alexander Fleming in the chair, concerned the preservation of mammalian cells, avian tissues and whole organisms at low temperatures. P. B. Medawar and R. E. Billingham showed that Malpighian cells of the epidermis of rabbit's ear skin could survive either very rapid *or* very slow freezing. These cells in grafts soaked in Ringer's solution did not survive slow thawing. Survival could be obtained, however, if the Ringer's solution contained 15 per cent glycerol. Suspensions of isolated epidermal cells would withstand slow freezing in this medium, but not in Ringer alone. It appears that slow freezing of skin grafts is, from all considerations, preferable to fast. B. J. Luyet, however, claimed that his results on the survival after freezing of muscle fibres, chick embryo amniotic muscle and heart, red blood cells, 'vinegar eels', frog spermatozoa, moss leaves and the epidermal cells of some plants confirm in general the predictions of the theory of vitrification by *rapid* cooling, especially with regard to (*a*) the necessity for a high freezing velocity together with subsequent rapid re-warming, (*b*) the beneficial effect of an initial reduction in water content, (*c*) the existence of a limited range of 'dangerous' temperatures, and (*d*) the innocuity of very low temperatures once they have been attained. He described techniques for the determination of cooling velocities which are capable of measuring speeds as high as 3×10^5 deg. C. per sec., and for obtaining such high velocities. R. D. Passey, L. Dmochowski and I. Lasnitzski discussed the freeze-drying of mouse tumours and the assessment of cell survival by growth of the rehydrated tissues in tissue culture or by grafting into susceptible mice. They stressed the need for reliable, non-destructive methods for the estimation of residual water in the dried tissue.

In the last paper of this session, A. S. Parkes gave the results obtained by himself and his collaborators (Miss A. U. Smith, C. Polge and H. A. Sloviter) on the survival after freezing of spermatozoa, endocrine tissue and red blood cells. Both fowl semen and bull and goat sperm withstood freezing in bulk to −79° C. in Ringer–glycerol and resumed full motility on thawing. Slow removal by dialysis of the glycerol from thawed fowl semen gave a sperm suspension with normal fertilizing power. The cumulus cells of rabbit ova grew in tissue culture after rapid (or slow) freezing of the ova in solid carbon dioxide or liquid air. Fragments of adult ovarian tissue similarly treated retained, after implantation, their endocrinological activity but the ova were destroyed. The freezing at −79° C. of whole rabbit or guinea pig blood diluted to a final concentration of 10–15 per cent glycerol was followed by recovery on thawing—even after three months of storage—and the glycerol could be removed by dialysis. The long-term storage of rare types of whole human blood and even of endocrinological 'spares' thus seems to be practicable.

The third session, with Dr. C. H. Andrewes in the chair, brought together papers on the freeze-drying of bacteria and viruses. R. M. Fry has found that suspending media for the drying of bacteria are improved by the addition of 5–10 per cent glucose or lactose, which he considers probably prevents the culture from being over-dried. In addition, a protective colloid is necessary for optimum results, and broth, serum, albumin, hæmoglobin or milk have been used. For especially delicate organisms such as *N. gonorrhœæ* and *V. cholerœ* a mixture of one part nutrient broth and three parts human serum, and containing 7·5 per cent glucose, gives optimum results. Similar conclusions have been reached by H. Proom from his experience in the preservation of more than 2,500 bacterial strains. A drying temperature lower than −30° C. is found to be essential and, so far as storage loss is concerned, two factors are important, namely, residual water content and the presence or absence of oxygen. It is therefore recommended that cultures should be given a secondary drying, sealed in dry, oxygen-free nitrogen or *in vacuo* and stored at the lowest practicable temperature.

R. Daubney described the units at Abbassia, Cairo, for the production of vaccines for veterinary use. Rinderpest vaccine, which freeze-drying has made available at very low cost, has, in a few years, given life-long protection to millions of native cattle of such low economic value that they did not warrant the expense of immunization by older methods. Dr. Daubney discussed the factors of preparation—desiccation, including the rate of application of heat to the drying product; residual moisture and temperature of storage of the dried product—all of which determine to a more-or-less extent the overall loss in viability of the ultimate product.

I. A. Galloway, L. H. Collier and Wilson Smith contributed papers on problems they have encountered in drying viruses, vaccines and anti-sera, and

S. T. Cowan dealt with two aspects of infection in drying procedures: cross-infection in the vacuum chamber where different organisms are being dried at the same time, and human infection as a result of aerial contamination of the room in which ampoules are being filled or of lack of care in handling and opening dried cultures.

The final session, with Prof. J. F. Danielli in the chair, comprised four papers on tissue fixation by freezing and drying. I. Gersh stressed the importance of techniques which would preserve cell structure for specific purposes in a state which approximated as closely as possible to that which is obtained in the living state, and gave an example in the use of polyethylene glycol in the infiltration of dried tissues, such as adrenal, for the excellent preservation of lipids. The calculations of J. L. Stephenson have shown that the limiting factor in the speed of withdrawal of water from frozen tissues is not the size or design of the vacuum system but the resistance of the dry tissue mass to the passage of further water vapour.

The papers and illustrations of B. Sylven, of F. Sjöstrand and of L. G. Bell show, beyond doubt, that the disadvantages such as dissolution of cell contents, diffusion within the cell, chemical reaction and physical change of common fixing procedures can largely be avoided by freeze-drying. However, the cell proteins might still be denatured, and it is also most important both that the existence of ice-crystal artefacts should be recognized, and that subsequent cytochemical operations upon dried material should be carefully controlled.

Various aspects of the techniques were discussed, and the meetings may be considered to have served their purpose if, in the opening words of Dr. Greaves, "in the pooling of our ideas . . . our knowledge of this most useful technique may be advanced". The full proceedings of the symposium will be published by the Institute of Biology (Tavistock House South, Tavistock Square, London, W.C.1).

R. J. C. Harris

DRY OXIDATION AND WET CORROSION*

By Dr. U. R. EVANS, F.R.S.
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TWENTY-FIVE years ago it was customary to draw a sharp contrast between high-temperature oxidation (then regarded as a simple example of direct combination between metal and non-metal) and wet corrosion at low temperature (a complex electrochemical phenomenon). The fact that the alloying constituents—chromium, aluminium and silicon—added to combat the first trouble often serve to prevent the second suggests that the two phenomena are not wholly disconnected. An attempt is made in this article to present an interpretation which covers them both.

High-temperature Oxidation. Metal heated in air becomes covered with an oxide film, which increases in thickness, rapidly at first, but then more slowly. The fact that the film continues to thicken at all indicates that either oxygen must cross it (moving inwards) or metal must cross it (moving outwards). It is now known that metal moves outward as cations and electrons; the electrons arriving at the outer surface convert any adsorbed oxygen atoms into ions, while the metallic cations take their place between them, giving an additional layer of oxide. Thus new oxide is built up continuously on the *outside* of the oxide-film. This outward movement of metal is met with also in the case of sulphide films and is responsible for the curious fact, recorded by Fischbeck and Dorner[1], that a copper wire exposed to liquid sulphur gives a *hollow tube* of sulphide.

Much evidence for outward movement was provided by Pfeil[2], while Wagner[3] and Mott[4] have put the matter on a quantitative footing. The oxidation-rate depends on the *electrical* properties of the *oxide*, and where these are known the oxidation-rate, calculated from electrical data, agrees well with that measured directly; the comparisons between calculated and measured values of film-growth provided by Wagner[3] include films not only of oxide but also of sulphide, bromide and iodide. Evidently, any film which resists the passage *either* of cations *or* of electrons should be protective; that is probably the cause of the protective quality of oxide films containing chromium, aluminium and silicon, and explains why, when these elements are added to iron and other metals, they confer resistance to high-temperature oxidation.

Oxygen in Wet Corrosion. The corrosion-velocity of metal immersed in water is connected with rate of replenishment of oxygen at the metallic surface and can be altered by moving the metal more quickly through the liquid or, under stagnant conditions, by increasing the oxygen-pressure in the gas mixture above the liquid. In general, the corrosion-velocity first increases with the rate of oxygen-replenishment, reaches a maximum and then decreases. For iron or zinc in neutral or weakly acid liquids, the maximum occurs at a high replenishment-rate, and under ordinary conditions oxygen is a 'stimulator' of corrosion. In alkaline liquids, the maximum occurs at a lower replenishment-rate[5] and oxygen can sometimes be regarded as an 'inhibitor'. Also, certain other inhibitors are only effective in presence of oxygen; the chalky protective film, which allows some hard waters to be run through steel pipes without bad results, is only satisfactorily produced in the presence of oxygen; Haase[6] states that organic reducing-agents interfere with its formation and should be destroyed with hypochlorous acid. For stainless steel[7] and aluminium[8], oxygen often reduces the corrosion-velocity—even in acid solutions.

When pure iron[9] or zinc[10] is whirled rapidly in pure distilled water containing oxygen, it undergoes no appreciable change and no visible corrosion-product appears in the liquid; placed in the same water containing the same oxygen under stagnant condition, iron soon develops rusty spots and zinc develops white spots, below which pits are found. Under whirling conditions the rate of replenishment of oxygen is high, permitting an invisible oxide-film to be formed by the outward movement of cations and electrons indicated above; the rate of thickening becomes extremely slow at a very low value of the thickness—the film being still invisible. (The film formed on unheated metal exposed to dry air is also invisible; the oxidation, which can be detected gravimetrically, electrometrically or optically, prob-

* Substance of a lecture delivered at a joint meeting of the Chemical Society (London) and the University of Birmingham Chemical Society, held in the Chemical Lecture Theatre, University of Birmingham, on October 26.

ably occurs mainly at sensitive spots—a term explained below—and soon becomes extremely slow.)

If, however, zinc is immersed in stagnant water, the replenishment-rate of oxygen becomes low; there is now a risk that at 'sensitive' spots cations may arrive at the external surface more quickly than oxygen arrives and can then escape into the liquid as hydrated ions, so that local corrosion, leading to pitting, occurs; a sensitive spot may be a place where the film is thin or cracked or rich in lattice defects, or a point where, owing to local strain in the metal, there is an abnormally high supply of high-energy cations which can move outwards more quickly than they can be 'arrested' by the oxygen. If the material is stainless steel or aluminium, and builds a highly protective film-substance, a much slower replenishment-rate suffices to ensure the arrest of the outward-moving cations, and it is not necessary to 'whirl' the specimens in order to avoid corrosion; nevertheless, oxygen is needed, and some liquids, which do not normally attack stainless steel or aluminium, produce corrosion if all the oxygen is eliminated. We see why those elements (for example, aluminium, chromium and silicon) which confer resistance to high-temperature oxidation, often confer resistance to low-temperature wet corrosion, and also why corrosion sometimes starts at crevices inaccessible to oxygen.

Electrochemical Mechanism. If on zinc or iron placed in a dilute salt solution the oxygen replenishment is insufficient to arrest the emerging cations at a sensitive spot, they will emerge into the liquid as hydrated ions (unless the liquid contains an anion forming a nearly insoluble salt, or a substance which prevents emergence in some other way). However, the emergence of cations must leave an excess of electrons in the metal, and the negative charge would halt the process unless the electrons were used up in reducing oxygen, either to hydrogen peroxide or to hydroxyl. A rate of oxygen-replenishment which is insufficient to arrest the cations emerging at the sensitive spot may nevertheless serve to use up the electrons left in the metal, since this can occur anywhere on a relatively large area around the sensitive spot. The two reactions can proceed without hindrance—the 'anodic reaction' (the passage of cations into the liquid at the sensitive spot), and the 'cathodic reaction' (the reduction of oxygen at the area around it); the migration of anions and cations through the liquid towards the anodic and cathodic areas prevents accumulation of charge anywhere.

Thus we have arrived—by an unfamiliar argument—at the well-accepted electrochemical mechanism of corrosion. The idea that the 'film theory' and the 'electrochemical theory' are rivals is clearly wrong; each expresses the same essential idea—approached from a different angle. It may be doubted, however, whether the word 'theory' should be applied to the electrochemical mechanism, which is to-day established on a firm experimental basis; the currents passing between cathodic and anodic areas have been measured by six independent experimental methods and been found equivalent to the corrosion-velocity measured chemically or gravimetrically.

Inhibitors. With iron in saline water (say, a dilute sodium chloride solution), very rapid whirling is needed before oxygen can act as an inhibitor[11]. Normally, oxygen helps the corrosion both of iron or zinc, since the corrosion products (iron or zinc chloride at the anodes, and sodium hydroxide at the cathodes) are freely soluble, and the solid oxides or hydroxides (rust in the case of iron) are only precipitated where they meet at a perceptible distance from the corrosion site. But if sodium phosphate or sodium hydroxide is present, a supply of oxygen otherwise insufficient may now suffice to stop attack, since any cations which are not arrested by the oxygen can be arrested by the phosphate or hydroxyl ions. Thus Mayne and Menter[12] have found, by electron diffraction, that the invisible protective film formed on iron placed in sodium orthophosphate solution containing oxygen consists partly of gamma-ferric oxide and partly of hydrated ferric phosphate. Likewise, Pryor and Cohen[13] have shown that, in the *p*H-range between 7·2 and 10·0, phosphates completely prevent corrosion in the presence of oxygen but fail to prevent it if oxygen is absent. The amount of phosphate—or other inhibitor—has to be increased if chlorides are present.

Corrosion by aqueous solutions is complicated by the fact that these always contain hydroxyl ions which may serve to arrest emergent cations under some conditions, since the hydroxides of most heavy metals are sparingly soluble. As to whether a solution of sodium chloride (or sulphate) will attack a metal, producing its soluble chloride (or sulphate), or build a protective layer of hydroxide (or oxide), depends largely on the *p*H value, which may itself be changed by the incipient reactions. The principles involved are discussed elsewhere[14]. Evidently, although there are analogies between high-temperature oxidation and wet corrosion, there are also differences.

Effect of Sulphur. It has been shown why certain alloying additions (chromium, aluminium and silicon) which retard high-temperature oxygen often prevent low-temperature wet corrosion. The same reasoning shows why certain other elements, particularly sulphur, enhance both types of attack. Copper, like most other metals, suffers no visible change if exposed to pure air at ordinary temperatures; a film is formed, but its rate of thickening becomes very slow while it is still invisible[15]. However, copper exposed to air containing a trace of hydrogen sulphide gives the same sequence of interference tints as is obtained in pure air at a slightly raised temperature[16,17]. The presence of foreign (sulphur) atoms in the oxide film favours the lattice defects and allows more rapid passage outwards, so that 'visible' thicknesses are reached at ordinary temperatures; other sulphur compounds present in town air enhance atmospheric attack. Sulphur plays a similar part in promoting wet corrosion. A polished iron specimen placed in a solution containing sodium chloride with sufficient inhibitor (sodium carbonate) to prevent corrosion over the greater part of the surface is nevertheless attacked locally around sulphide particles; inclusions of silicate and alumina do not act as sensitive spots[18]. The phenomenon is not shown by coarsely abraded iron, since the deformed material then provides sensitive spots which mask the effect of the sulphide inclusions.

Effect of Impurities. Atoms of a foreign metal can greatly reduce the protective character of an alumina film. A copper–aluminium alloy, if first heated under very feebly oxidizing conditions to produce an alumina film free from copper, shows far greater resistance when afterwards heated in oxygen than the alloy which is exposed to the strongly oxidizing conditions from the first—since, then, the film consists of alumina with copper oxide in solid solution[19]. Similarly, commercial aluminium containing iron and other impurities is much more attacked by

citric acid containing sodium chloride than pure aluminium, which forms a highly protective film; in the latter case the attack is localized[8] and may take the form of pitting, so that purity is not always an advantage.

It should be added, however, that this is not the only reason why impure metals are sometimes corroded more quickly than pure metals. Commercial zinc is attacked more rapidly by acids than pure zinc because the metallic impurities, passing into solution, are reprecipitated to form cathodes of low 'overpotential', on which hydrogen can readily be liberated.

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OBITUARIES

Dr. Harald Blegvad

THE science of marine biology has suffered a great loss by the death on August 22 of the director of the Danish Biological Station, Dr. Harald Blegvad. Blegvad was born on the small Danish island, Samsø, on July 24, 1886. When he had matriculated at the University of Copenhagen in 1904, he took up the study of natural history; he took the degree of M.Sc. in 1910 and in 1921 he obtained a doctorate for a thesis on the biology of some coastal Gammarids and Mysids.

Already as a student he took part in cruises with Danish research vessels in home waters and in the Atlantic. In 1908 he became assistant at the Danish Biological Station, and in 1931 he succeeded A. C. Johansen as director of the Station.

Blegvad's scientific work centred upon the study of the biology of the marketable fishes and of their food organisms. The long series of papers from his hand bear evidence to his keen eye for the essential points of the problems, and further of his clear understanding of what conclusions the material available allowed. His papers show that he possessed that sober self-criticism which is so indispensable to all true scientific work.

Blegvad combined science and practice, and his services to the fishery industry were manifold. He worked on the transplantations of plaice and cod, on the protection of fishes, and, on trips with fishing vessels, he tried new gear and helped the fishermen to find new fishing grounds. Through his personal contact with fishermen and by publishing popular articles and handbooks, he caused a growing understanding of the value of biological science to the fishery industry.

In the work of the International Council for the Exploration of the Sea, Blegvad played a great part; during 1931–45 he was chairman of the Transition Area Committee and since 1945 he had been general secretary to the Council.

As a result of his international reputation as a fishery expert, Blegvad was often called upon by foreign governments which wished to re-organize their fisheries. In 1928 he acted as fishery expert in Lithuania, during 1936–38 he was for two half-years in Persia, and in 1949 he worked for the Government of Ceylon.

By his friends and colleagues Blegvad was much appreciated for his fine, human qualities. He was kind, true and helpful, and his sudden death by heart-failure caused widespread regret.

ERIK M. POULSEN

Dr. E. G. V. Percival

THE death of Dr. E. G. V. Percival at Edinburgh on September 27, at the early age of forty-three, at the height of his powers as a teacher and investigator, is a serious loss to organic chemistry.

Edmund George Vincent Percival was born at Coalville in 1907 and was educated at King Edward VII Grammar School, Coalville, and at the University of Birmingham. After a brilliant undergraduate career he joined Dr. (now Prof.) W. Wardlaw in researches in inorganic chemistry. This experience was followed by a period with Prof. Harold Hibbert at McGill University, Montreal, where he undertook physico-chemical investigations in the field of cellulose chemistry.

With this wide background Percival returned to Birmingham as research fellow in Sir Norman Haworth's laboratories, where he speedily acquired the interest in carbohydrate chemistry which he maintained so vigorously to the end of his life. In 1933 he was appointed lecturer in chemistry in the University of Edinburgh, and was promoted to a readership in 1948. He was a member of the Faculty of Science, a director of studies and in 1951 he was elected a member of the Senatus Academicus. In addition to his University work, Percival gave generously of his services to the Royal Institute of Chemistry, the fellowship of which he had gained in 1936, and to the Society of Chemical Industry. He became a fellow of the Royal Society of Edinburgh in 1938. For many years he took an active interest in the work of the Pharmaceutical Society and of the Scottish Seaweed Research Association. In 1948, when the annual meeting of the Society of Chemical Industry was held in Edinburgh, and again in 1951 on the occasion of the meeting of the British Association, he played a notable part in securing the success of the local arrangements. He served with distinction on many committees, and at the time of his death he was a member of Council of the Chemical Society.

His interests were wide, including travel, gardening, tennis and cricket. He was an inspiring teacher and director of research, fertile in ideas and energetic in their development. In all his dealings he was supremely generous, and his kindness, understanding and loyalty endeared him to his many friends and colleagues.

Percival was the author of some seventy papers, dealing with the chemistry of the sugars. Among his achievements special mention may be made of his part in the elucidation of the structure of vitamin C, his work on the ring structure of osazones, on the alkali addition compounds of the sugars, on the molecular structure of plant seed mucilages, seaweed polysaccharides (notably agar, fucoidin and laminarin) and the naturally occurring fructosans. In all these subjects he had become a recognized authority, and his book (1950) on the "Structural Chemistry of the Carbohydrates" is a model of its kind.

In 1934 he married E. Elizabeth Kempson, herself a chemist who has collaborated in many of these investigations. She and their two children survive him.

E. L. Hirst

We regret to announce the following deaths:

Prof. R. B. Denison, formerly principal of Natal University College, and president in 1918 of the South African Chemical Institute.

Prof. Allan Ferguson, until 1945 assistant professor of physics in Queen Mary College, University of London, on November 9, aged seventy-one.

Prof. R. Sekiguti, lately director of the Tokyo Observatory, on August 10.

NEWS and VIEWS

Royal Society: Medal Awards for 1951

The following awards of medals have been made by the president and the Council of the Royal Society:

Copley Medal to Prof. D. Keilin, Quick professor of biology and director of the Molteno Institute, University of Cambridge, for his fundamental researches in the fields of protozoology, entomology and the biochemistry of enzymes.

Davy Medal to Sir Eric Rideal, professor of chemistry in King's College, University of London, for his distinguished contributions to the subject of surface chemistry.

Hughes Medal to Prof. H. A. Kramers, professor of theoretical physics in the Technical University, Delft, for his distinguished work on the quantum theory, particularly its application to the optical and magnetic properties of matter.

Physics at Leeds: Dr. J. G. Wilson

Dr. John Graham Wilson, reader in physics in the University of Manchester, has been appointed to the second professorship of physics at Leeds (rendered vacant by the succession of Prof. E. C. Stoner to the Cavendish chair, also at Leeds, on the retirement of Prof. R. Whiddington), and is to take up his new duties in June 1952. Dr. Wilson was born at West Hartlepool, Durham, in 1911, and was educated at the Grammar School there and at Sidney Sussex College, Cambridge. He carried out research for three years at the Cavendish Laboratory, Cambridge, under the direction of C. T. R. Wilson. He then joined P. M. S. Blackett as research assistant at Birkbeck College, London, and was later appointed assistant lecturer in the University of Manchester (1938). During the Second World War he was with the Air Ministry and the Ministry of Aircraft Production.

Dr. Wilson's first research was concerned with the development of new forms of expansion apparatus, which figured largely in his pre-war work on cosmic ray physics. He developed new methods of temperature control which made possible high-precision measurements of momentum above and below an absorbing plate placed in a cloud chamber, and, with Blackett, he made extensive measurements of the energy loss of cosmic ray particles in such plates. Since the War, his immediate work has mainly been in the design, construction and application of the momentum spectrograph for cosmic ray particles which has been built in Manchester. In addition to his papers, Dr. Wilson has written a valuable specialist book, "Principles of Cloud Chamber Technique", and an eminently readable general book, "About Cosmic Rays", and he has edited a volume on "Progress in Cosmic Ray Physics" which is to be published shortly. At Leeds, where most of the research is concerned with the solid state, in its atomic and electronic aspects, Dr. Wilson will greatly strengthen the representation of nuclear physics in the Physics Department. At the same time his keen interest in work with undergraduates will do much to ensure the maintenance of a proper balance between teaching and research.

Veterinary Science in the University of Queensland: Prof. John Francis

It is announced that Mr. John Francis has been appointed to the newly-established chair of preventive medicine within the Veterinary Faculty of the University of Queensland. This is the second professorship to be filled since the full five-year veterinary course was re-established in 1950, the earlier one being in animal husbandry (see *Nature*, **166**, 136; 1950). The designation of the two senior research and teaching posts within the young faculty in this manner serves to emphasize the present trend in veterinary science. The aim of reducing economic loss and animal suffering is being met by an increased application of pathological and bacteriological knowledge to the prevention of disease, while recent advances in animal physiology and genetics are being applied to increase the efficiency of animal production. Queensland, with nearly eight million cattle, eighteen million sheep and more pigs than any other State of the Commonwealth, and with the majority of its stock within the tropics, possesses many important unsolved epizootiological and ecological problems. The shortage of veterinarians is acute in every Australian State; but it is believed that the development of the Veterinary School of the University of Queensland will in time greatly help to overcome this.

Mr. Francis graduated from the Royal Veterinary College in 1938, having concurrently taken the B.Sc. degree of the University of London. He was for a

year demonstrator in bacteriology at the Royal Veterinary College before becoming a research officer at the Foot and Mouth Research Station, Pirbright. In 1943 he joined the Biological Department of Imperial Chemical Industries, Ltd., and studied the metabolism and antibacterial action of the sulphonamides and sulphones. This work has led to a better understanding of their application in veterinary medicine, and also to the use of 4 : 4′-diamino diphenyl sulphone for the treatment of leprosy; this sulphone is the first effective drug cheap enough to be used on a wide scale. The isolation of the growth-factor for *Myco. johnei*, first demonstrated by Twort and Ingram in 1913, has added to our knowledge of the acid-fast bacteria and may assist in the development of chemotherapeutic substances. In addition to his main work on the application of chemotherapy to veterinary medicine, Mr. Francis has developed a keen interest in many problems of epizootiology. This has been shown in recent years in his studies of bovine tuberculosis and the relationship of the bovine disease to that in man, on which he published a book in 1947. He was a delegate to the World Health Organization conference in Geneva last year, where recommendations were made for the control of 'zoonoses', or animal diseases transmissible to man.

Scientific Workers and Defence Research in the United States

A STATEMENT on scientific workers and mobilization, issued on September 12 by the Science Advisory Committee of the United States Office of Defense Mobilization, makes a number of suggestions regarding the participation of universities or academic men of science in research on defence in America. The Department of Defense has already expanded its research and development to more than double that of the late 1940's, mainly in industry and government laboratories, and only about 10 per cent of it represents work done on contract with universities. The statement expresses the view that the major part of the academic research effort of the United States should, in present circumstances, continue to be devoted to fundamental research, but that there should be an appropriate balance between academic science and the abnormal and immediate demands of military problems. A substantial portion of the academic effort should accordingly be devoted to urgent defence needs and to building up throughout the academic community a widespread knowledge of the scientific problems of defence and a reserve of scientific workers to meet emergencies.

The statement suggests that outstanding men should be made available to projects which analyse military objectives in a broad area of technology and possible means of achieving them, and also to other defence activities where they can simultaneously learn research needs by participating in them. Specially qualified leaders should be given leave of absence to take positions in the Department of Defense and other government agencies which will familiarize them with the problems needing attention. Universities and colleges, it is suggested, should welcome opportunities for joint projects. To a considerable extent the best place for an individual scientific worker depends on whether his own interest and aptitude are for fundamental research and teaching or for applied research or administrative work on defence projects. Periods of leave for such defence work should be of specified duration, both to prevent undue interruption of an individual's normal activities and to spread participation in defence research. The importance to the United States of research and teaching is a major consideration. With these conditions the Committee believes that research and teaching activities would also benefit by widening the experience of scientific workers. The signatories to the statement include the chairman, Dr. Oliver E. Buckley, and Dr. D. W. Bronk, Dr. L. Dubridge, Dr. J. R. Killian, Dr. R. F. Loeb, Dr. J. B. Conant, Dr. J. R. Oppenheimer, Dr. C. A. Thomas, Dr. A. Waterman, Dr. H. Dryden and Dr. W. Whitman.

French Palæontological Documentation and Translation Service

THE Centre d'Études et de Documentation Paléontologiques, Muséum d'Histoire Naturelle, Paris, was set up in 1947 with the aim of providing the palæontological documentation required by the modern research worker in the different branches of the sciences of the earth. In addition to supplying general bibliographical information, the Centre has developed its translation service and provides, for scientific workers in France and elsewhere, French translations of recent publications in other languages, in particular, in Dutch, German, Polish and Russian. It has concentrated on the two types of translation: articles on subjects which are of particular interest at the present time, such as tectonics (and in particular neotectonics), sedimentation, the Quaternary era and evolution; and, within the field of palæontology, translation of works on systematics, especially of those written in Russian, in order that descriptions of new forms should be readily available. So far, nearly four hundred translations have been made, 80 per cent of them being of Russian, Polish or Dutch works. The three-monthly bulletin published by the Centre gives the titles of the new translations as they are prepared, and complete lists of all the translations made since the Centre was set up can also be obtained. At the request of other organizations or research workers, the Centre also carries out special translations, and these and the diagrams can be easily reproduced. The charges for reproductions of translations are approximately 10*d*. per page of text, plus 2*d*.–1*s*. each for photostats of the diagrams, depending on the size. Further information can be obtained from J. Roger, Centre d'Études et de Documentation Paléontologiques, 3 Place Valhubert, Paris 5e.

Preparation of Manuscript for Publication

UNDER the title "Preparing Technical Material for Publication; a Manual for Authors of College and Station Publications", the University of Illinois Engineering Experiment Station has issued as Circular Series No. 62 (pp. 39; Urbana: University of Illinois, 1951; 60 cents) a revised and enlarged edition of the manual "Preparation of Manuscript" published by the Station fifteen years ago. It deals especially with the publications issued by the Experiment Station and by the College of Engineering, alone or in collaboration with other divisions of the University, including recommendations for the preparation of manuscript and illustrations and also for proof-reading. Much of the material, particularly in the first three chapters relating to the range and form of publications issued by the Station and College, is concerned with the characteristic style or form of those publications; but the succeeding

chapters, dealing with content and preparation of copy, contain comments and observations of general validity. While much of this is thoroughly sound, there is little to justify commending the manual to British, as distinct from American, writers, particularly in view of the recent flow of British publications of this type, among which it should suffice to mention the "General Notes on the Preparation of Scientific Papers" issued last year by the Royal Society and which itself gives a representative list of British reference books. The bibliography included in the Illinois manual is entirely American and, even so, omits two of the best American books: S. F. Trelease's "The Scientific Paper" and J. R. Nelson's "Writing the Technical Report". There is a further reason for caution in recommending this manual to British readers. While the principles of arrangement and construction are independent of language, when it comes to the handling of words, the fact that the manual is written in English can disguise the truth that British and American writers are really dealing with two different languages. The same words quite commonly have different meanings or nuances. This is apt to give the impression, which sometimes may be quite mistaken, that American writers do not handle their tools with the same precision or show the same regard for style as their British confrères.

Physical Society: Meeting at Southampton

The autumn provincial meeting of the Physical Society will be held in the Physics Department of University College, Southampton, during December 18–19. The meeting will be divided into three sessions on the following subjects under the direction of the persons indicated: (1) optics of metals (Prof. A. M. Taylor); (2) thermal properties and growth of crystals (Mr. S. Weintroub); and (3) complex spectra and nuclear structure (Prof. H. A. Jahn). In addition to contributions from the Departments of Mathematics and Physics of University College, Southampton, papers will be presented by members of the Physics Departments of the Universities of Birmingham, Bristol, London (Royal Holloway College and Guy's Hospital), Oxford and Reading, and of the South-West Essex Technical College, Walthamstow, the Atomic Energy Research Establishment, the Telecommunications Research Establishment, the British Scientific Instrument Research Association, and Hilger and Watts, Ltd. The meeting is open to non-members of the Society. Application forms and further information can be obtained from the Secretary-Editor of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Awards for Technical Writing on Radio

To encourage the writing and publication of articles reporting technical progress and development in radio and electronics in Great Britain, the Radio Industry Council is to award premiums of twenty-five guineas each, up to an average of six a year, to the writers of published articles which, in the opinion of a panel of judges, deserve to be commended by the industry. It is hoped in this way gradually to increase the number and standard of articles available to editors. Any non-professional writer will be eligible, and the awards will be made for articles published in Great Britain or abroad in papers or periodicals which can be bought by the public on the bookstalls or by subscription. Writers and editors will be invited to submit published articles to the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1 (if possible, five copies of the journal, proofs or reprints), for consideration. The judges will be asked broadly to take into consideration the value of an article in making known British achievement in radio and electronics, originality of subject, technical interest and presentation and clarity. The judges will be four members of the Radio Industry Council, and Prof. Willis Jackson, professor of electrical engineering, Imperial College of Science and Technology, University of London, assisted by the editors of *Wireless World* and *Electronic Engineering*.

Gas Council Research Committee

Additions to the membership of the Gas Council Research Committee have been appointed as follows: J. H. Dyde, president of the Institution of Gas Engineers; G. le B. Diamond, chairman of the West Midlands Gas Board; Prof. F. H. Garner, professor of chemical engineering, University of Birmingham, and part-time member of the West Midlands Gas Board; and Dr. F. J. Dent, director of the Gas Council Birmingham Research Station. The Committee was established in September of last year with the responsibility of advising the Gas Council on all matters connected with research, drawing up programmes and reviewing progress from time to time.

Announcements

The American Society for the Study of Sterility is offering a prize, with a cash award of 1,000 dollars, for the most outstanding contribution to the subject of infertility and sterility, as judged from among essays submitted for this competition, which must be received not later than March 1, 1952. Further particulars can be obtained from the Society at 20 Magnolia Terrace, Springfield, Massachusetts.

Applications for grants from the Clough Memorial Research Fund of the Edinburgh Geological Society are invited for the period April 1, 1952–March 31, 1953. This Fund was instituted in 1935 for the purpose of encouraging geological research in Scotland and the North of England, the latter being defined as comprising the counties of Northumberland, Durham, Cumberland, Westmorland and Yorkshire. Applications must be in the hands of the Secretary, Clough Memorial Research Fund Committee, Edinburgh Geological Society, Synod Hall, Castle Terrace, Edinburgh, 1, not later than March 1, 1952.

The Institution of Naval Architects has made the following awards: 1851 Exhibition Commissioners Postgraduate Research Scholarship in Naval Architecture (1949), of £500 a year, to I. M. Yuille, for one further year; Sir William White Postgraduate Scholarship in Naval Architecture (1951), of £150 a year for two years, to M. C. Eames, of King's College, Newcastle upon Tyne; Aluminium Development Association Research Scholarship in the Application of Light Alloys to Ship Construction (1949), of £400 a year, to J. B. Caldwell for one further year; Elgar Scholarship in Naval Architecture (1951), of £175 a year for four years at the University of Glasgow, to R. R. Phillips, of H.M. Dockyard, Devonport; Vickers-Armstrongs Scholarship in Naval Architecture (1951), of £220 a year for three years at King's College, Newcastle upon Tyne, to G. A. Smith, of Aldous Successors, Brightlingsea.

PRE-BREAKDOWN DISCHARGES IN D.C. POSITIVE POINT TO PLANE CORONA

By H. M. GAUNT and Dr. J. D. CRAGGS
Department of Electrical Engineering, University of Liverpool

PREVIOUS workers[1-4] have shown that D.C. positive point to plane corona in air and in other gases of moderate purity consists of several forms of discharge. These are, in order of appearance with increasing voltage, burst pulses and pre-onset streamers, burst corona and finally streamers the lengths of which increase with voltage until one of them crosses the gap and gives rise to a spark.

Recently it has become apparent that a further discharge is present in conditions suitable for streamer formation. In D.C. coronas, this discharge is of a filamentary nature, and, it is submitted, should be clearly distinguished from streamer discharges. It will be referred to in this article as the 'filamentary' or 'diffuse discharge'.

Discharges have been found in impulse corona, mainly by Saxe[5,6], Komelkov[7,8] and others[9-11] which differ from the classical streamers[1-4,12]. Confusions in nomenclature have arisen; but in the present discussion a streamer is taken to be a filamentary discharge which, on crossing the discharge gap, leads to a breakdown.

Discharges in air. A photograph of pre-breakdown corona in air, taken with a small aperture and long exposure, is shown in Fig. 1. Three distinct regions are visible: (*a*) a very intense glow, localized at the point surface; (*b*) an intense discharge directed outwards from the point in a straight line along the axis of the gap with a fairly sharp termination; and (*c*) a fainter continuation of zone *b* which spreads out into a diffuse luminous cone; only the more intense part of the latter discharge is visible in Fig. 1 because of the small aperture used. (*a*) is probably a region in which a succession of avalanches moves into the point, as in burst corona; (*b*) is the region of the pre-breakdown streamers which are limited in extent to the high-field region around the point; and (*c*) shows the diffuse discharges which have a filamentary structure.

The electrode geometry has little effect on the discharge.

The filamentary discharge (*c* above) has been studied with a photomultiplier – video amplifier – oscillograph technique. Light pulses from two small regions of the discharge, one near the streamers and one near the plane, have been displayed on the oscillograph screen so that, knowing the distance apart of the two observed regions and the time displacement of the pulses observed on the screen, the velocity of propagation of the filamentary discharges towards the plane could be measured. The mean velocity across the gap was thus found to be $\sim 10^7$ cm./sec., which is of the same order as the lower published values for streamer velocities.

A further experiment was carried out to test for simultaneity of the streamers and the filamentary discharge. A photomultiplier tube and amplifier were used for displaying light pulses from the streamers on one beam of a double-beam oscilloscope, while another photomultiplier and amplifier displayed light pulses from the filamentary discharge on the other beam. The coincidences of the pulses showed that the streamers and the filamentary discharge occurred more or less simultaneously.

Light pulses from two separate parts of the filamentary discharge, situated on opposite sides of the axis, were recorded with the above apparatus. Simultaneous pulses showed that many filaments are propagated at once. These experiments suggest that the discharge consists of an intense streamer extending

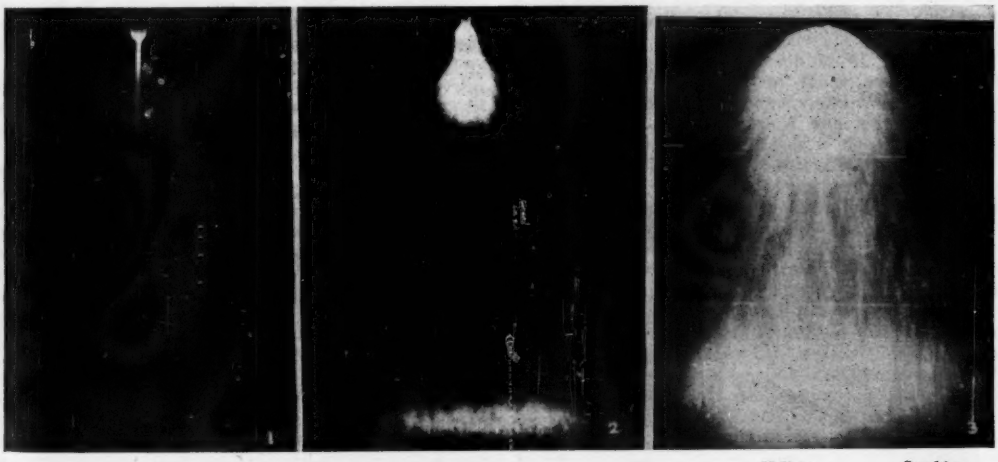

Fig.	Gas	Gap length (cm.)	Point diam. (mm.)	Camera exposure	Voltage of fig. (kV.)	Sparking voltage (kV.)
1	Air	5·6	1·5	60 sec. : *f*/6·3	34	37
2	Nitrogen	7	0·2	2 sec. : *f*/1·5	36·5	37
3	Argon	5·8	0·2	5 sec. : *f*/1·5	—	—

a few millimetres from the point with many less intense filaments being propagated from the streamer to the plane, with a possible continuous luminous background. The whole discharge occurs in about a microsecond, repeating every few hundred microseconds.

If the voltage drop along the streamer is negligible, the applied voltage will appear across the filamentary discharge. In typical conditions, some 30 kV. is thus applied to filaments about 5 cm. long so that the mean potential gradient is roughly 6 kV./cm., to be compared with Komelkov's figure[6] of 6–8 kV./cm.

Discharges in nitrogen. The appearance of the corona discharge near spark breakdown in nitrogen differs greatly from that in air. The streamers in nitrogen are much longer and more erratic than in air and are often branched at their extremities (Fig. 2). In nitrogen of commercial purity, the filaments in the filamentary discharge are apparently fewer and less diffuse than in air; there is also a large increase in intensity of the filaments very near the plane (Fig. 2), although occasionally this increased, intensity occurs along about 3–4 mm. of filament.

The addition of a few per cent of air shortened the streamers and tended to concentrate them along the axis. Ultimately, as the proportion of air increased the discharge tended gradually to that observed with air.

Discharges in argon. The corona in argon resembled that in nitrogen, showing long erratic streamers, in general agreement with Weissler[4]. The filaments were intense in regions very near the surface of the plane electrode (Fig. 3).

The effect of adding air was less than might be expected from Weissler's results[4], since several per cent of this contaminant merely produced a slight rise in starting voltage and little alteration in the appearance of the discharge.

Discharges in oxygen. The corona in oxygen was very faint, as in hydrogen, even though the applied voltage was about 65 kV. compared with 30 kV. in the other gases. Streamers were visible before breakdown, extending a few millimetres from the point as in air. The filamentary discharge was invisible except for a faint glow near the tips of the streamers and a glow near the plane electrode which was so faint that it was scarcely visible.

Discussion. If the discharges referred to above as 'streamers' are those of the Loeb–Meek–Raether theory, as seems likely since the filaments bridge the gap without causing spark breakdown, then it is desirable to seek a mechanism for the filaments. This point will be discussed later; but for the moment it will be assumed that the streamer theory is not applicable to the filamentary discharge. At present it does not seem possible to formulate a definite mechanism, and this discussion will be concerned with certain suggestions and general tentative conclusions.

The filamentary structure of the discharge, its high velocity of propagation, and the direction of propagation of the filaments all suggest a streamer type of mechanism. The tendency to follow lines of force, the lack of spark breakdown when the filaments bridge the gap, the low intensity and, possibly, the high axial potential gradients suggest that the filaments have lower ion densities than streamers, resulting in less field distortion.

The increased luminosity near the plane can be readily explained if the discharge does, in fact, consist of continuous conducting filaments, since the field between the tip of a filament and the plane cathode will be high when the distance between them is small. This field intensity may be high enough to permit true streamers to be formed near the plane, or may merely increase the intensity of the filaments. Photoemission from the plane probably contributes. It also seems possible that the enhanced intensity is due to a negative leader[10,12] developing from the cathode.

It is known[13–15] that there exists, in certain gaseous discharges, photons which are absorbed less readily than those usually considered to be involved in streamer propagation[12]. Any such photons produced by a streamer will probably cause weak ionization at appreciable distances from the streamer tip. Any photoelectrons so produced will move slowly towards the point, and such of these photoelectrons as find themselves near the tip of the filament may create avalanches which feed into the filaments. It seems possible that it is these avalanches, initiated by the streamer or burst corona, that enable the filaments to be propagated in low fields.

Loeb[16] discusses this discharge in pre-onset D.C. corona, but does not refer to its filamentary structure; and indeed it would be very difficult to observe such a structure in the small pre-onset discharges. He suggests that the discharge is caused by photon absorption some distance from the main streamer channel, and that the photoelectrons so produced move towards the streamer channel along the lines of force, ionizing and exciting atoms in their path. This would give rise to an extended diffuse glow and is inconsistent with many properties of the discharge.

In impulse corona, Saxe and Meek[5,6] have also suggested that the discharge consists of a zone of continuous ionization. Their photomultiplier technique could not by itself reveal the filamentary structure which is apparent in photographic work by Allibone and Meek[10], Garfitt and Meek[17] and others[7,8,11,18].

Other authors[7,8,18] apparently consider that the theory of streamer propagation[12] applies to the filaments and that the breakdown streamer (or leader stroke) is, in some way, formed from these filaments. If this view be accepted, it becomes difficult to account for the absence of a spark when the filaments bridge the gap, which they do at voltages considerably below the sparking potential.

Conclusions. It is now fairly well established that there exists a filamentary but extensive discharge apparently associated with the streamer discharge in inhomogeneous field breakdown.

Since the above work was completed, more than a year ago, new data on breakdown processes in uniform field gaps at high pressures (some hundreds of millimetres of mercury) have been obtained by Fisher and Bederson[19,20] and by Llewellyn Jones and Parker[21]. The former, from a study of formative time-lags at small overvoltages, have suggested that, especially for the rare gases, as described earlier by other authors[22,23], the streamer theory does not apply (at least in its simple form) for low overvoltages, and may be replaced by a Townsend mechanism. For non-uniform field gaps, it is more difficult to explain breakdown by cathode effects, particularly when impulse voltages of short duration are used, although the discharges shown in Figs. 1–3, and notably the argon discharge shown in Fig. 3, show that discharge effects take place at the cathode. The latter authors[21] reject the streamer theory, for uniform field and for point-plane gaps.

Calculations of the field at the plane electrode in point–plane gaps during D.C. corona discharges have been made by Loeb and Meek[24]. Negative-point discharges were studied and it was shown that fields of ~30 kV./cm. or more might be established at the plane electrode.

We wish to thank Prof. J. M. Meek, Mr. W. Hopwood and Dr. R. F. Saxe for many discussions on streamer mechanisms. One of us (H. M. G.) wishes to acknowledge financial support from the Electrical Research Association and also from the Stoke-on-Trent Education Committee.

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SUPERPOSITION EFFECTS IN MULTIPLE-BEAM INTERFERENCE FRINGES

By AUDREY M. GLAUERT*
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THE Fizeau fringes given by a pair of flats, placed at a small angle to each other, are straight, lying parallel to the edge of the wedge. If the flats are silvered and the monochromatic illumination is correctly collimated, the fringes are formed by multiple reflexions and are very sharp[1]. If, however, an ordinary thin microscope coverslip is introduced between the flats the appearance of the fringes alters. In the area occupied by the coverslip the fringes are distorted and modulated to a considerable extent (Fig. 1, × 12).

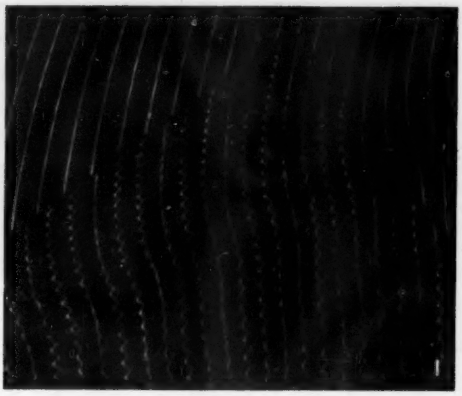

Fig. 1

Corresponding results are obtained if a thin unsilvered slip of mica is placed between the flats; but further unusual effects also occur. Owing to the birefringence of the mica, each fringe is doubled, the light forming the two components being polarized in mutually perpendicular directions. A striking phenomenon is that the two components of a fringe are not modulated in a similar manner in all regions. One component may be practically straight at a place where the other is distorted, while in other parts of the field the effect may be reversed. In some regions both components will appear straight or both curved. This difference in behaviour seems to indicate that the modulation is dependent upon the state of polarization of the interfering light. The effect is illustrated in Fig. 2 (× 15). In (*a*) both sets of fringes are present, whereas in (*b*) and (*c*) a 'Polaroid' has been introduced to exclude one or other of the components. In Fig. 3 (× 12), half the field is covered by the modulated fringes, while the other half shows the 'contour' fringes formed between one side of the mica lamina and the nearest optical flat. The close connexion between the distortions of the wedge fringes and the shape of the contour fringes is clear, and suggests that the modulation effect is due to the superposition of the various fringe systems formed

* Now at Strangeways Research Laboratory, Cambridge.

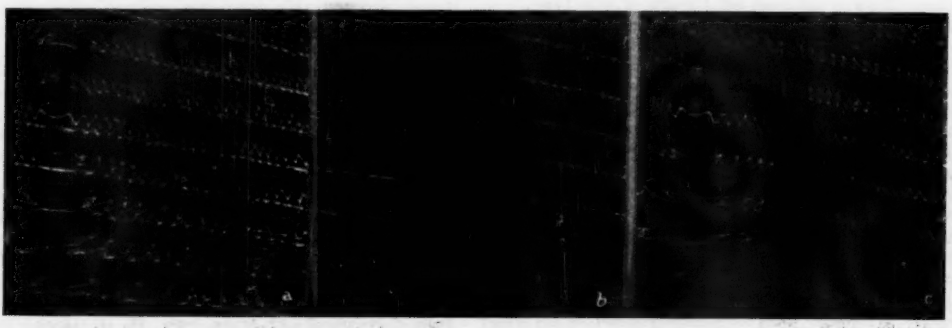

Fig. 2

Fig. 3

Fig. 4

between the mica and the flats. Finally, in Fig. 4 (× 9), the fringes are shown at high dispersion with the flats lying practically parallel. The right-hand side of the figure shows the contour fringes formed between one silvered side of the mica and the nearest flat, and the left-hand side those between the other silvered side of the mica and the other flat. The central region shows the modulated fringes at high dispersion. In part of the field one component of the fringes remains practically unaffected, while the other is greatly modulated. However, this effect changes considerably as the fringes cross a cleavage step in the mica which can be seen running diagonally across the figure. On the other side of the step the components are equally modulated. This change in behaviour of the modulations on crossing a step was often observed and suggests that the superposition effect is also dependent upon the thickness of the inserted lamina. This is presumably due to the fact that the relative sizes of the relevant air gaps are changed.

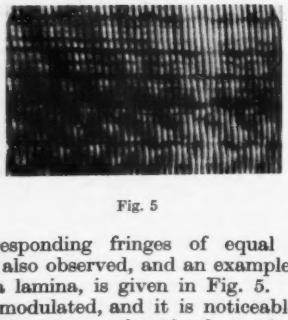

Fig. 5

The corresponding fringes of equal chromatic order[1] were also observed, and an example, obtained with a mica lamina, is given in Fig. 5. Again the fringes are modulated, and it is noticeable that the fringes at different wave-lengths do not have similar shapes. This is unusual for fringes of this type.

The full explanation of the effects described here remains obscure, but as it is no longer possible to continue the investigation it was thought best to communicate the results in their present form. They have importance, particularly with respect to interference experiments carried out to study the structure of biological material. It is often proposed to place a specimen under examination in a suitable fluid between silvered optical flats, in the hope that the resultant fringes will give some indications as to structure and form. The present results show that the greatest care must be taken in the interpretation of such interferograms, and they illustrate the ease of production of artefacts. [June 13.

[1] Tolansky, S., "Multiple Beam Interferometry of Surfaces and Films" (Oxf. Univ. Press, 1948).

RACIAL STUDIES

UNESCO's two recent pamphlets, "Race and Psychology" and "The Roots of Prejudice"*, have only their topic in common. Dr. Klineberg's essay is exactly what one would expect from the leading authority on the subject he discusses—a concise statement, rich in usefully selected data, leading to the conclusion that there is "no relation between race and psychology". He admits, of course, that "individuals and families are not equally endowed", and he recognizes the importance of heredity in accounting for differences in mental ability; but he insists that there is "no evidence" for the view that "races or ethnic groups differ in their psychological inheritance. . . . As far as we can judge, the range of capacities and the frequency of occurrence of various levels of inherited ability are about the same in all racial groups."

This is now the prevailing opinion among serious scholars, though an influential minority still rejects it. But, whether one agrees or not, the value of easy access to a factually presented argument for this belief is evident. Students and teachers will certainly find it useful, while those who indulge in racial opinions should at least be discomfited by it.

Dr. Rose's opinionative discourse, on the other hand, is of interest chiefly as an example of the unscientific lengths to which a synthesis embracing recent psychiatric theories, restricted personality studies, uncontrolled speculations and American idealism can be pushed. There are more facts about the nature of prejudice in the records of ancient civilizations, and more about its psychology in Antarah, Ibn Khaldun and Vico, than in the entire body of influencing factors and half-truths sometimes described as "the psychology of race relations"; but Dr. Rose's approach does not include their consideration.

Ibn Khaldun, for example, suggests slavery as a major source of prejudice against Jews and Negroes, and those who know the history of these groups will appreciate his point. Dr. Rose's thinking, however, shapes the astonishing statement that "prejudice was not particularly associated with slavery" in the United States. He prefers the metonymic explanations of the day: "Frustration explains the force behind prejudice. But it does not explain why certain minority groups are chosen as scapegoats. To explain this, psychologists help us out with another theory—the 'symbolic' theory. This theory is based on the important fact that one thing can stand for something else in the unconscious mind."

This process of substitution or symbolization produces unfavourable attitudes against substitutes for "important things in the culture" which engender inadmissible fears, dislikes and rebelliousness. For example, "some people will not admit that they would like to rebel, and these are usually the ones who would most like to do so. They pretend that they adore their parents at all times, that they have 'pure' feelings about sex and religion and so on. Since this is not *really* the case, they have to give vent to their rebel feelings in some way. And they do so by having prejudices against minority groups." Why *certain* minorities are selected, if they are, we are not told, except in terms of fears of large numbers, power and "spying for foreign governments".

* (1) "Race and Psychology." By Otto Klineberg. Pp. 39. (2) "The Roots of Prejudice." By Arnold Rose. Pp. 41. (Paris: Unesco, 1951; London: H.M. Stationery Office.) 1s. 6d. each.

It would be carrying criticism too far (perhaps it would be fear of psychiatry) to deny that such explanations represent facets of truth. In fact, the defect of Dr. Rose's propaganda lies not so much in their use as in the manner of their employment: they are out of proportion, without historical pattern, and suffused by a kindergarten brightness that can only be tiresome to adult minds. Moreover, over-anxiety to make a case provokes the very questions he tries to avoid. Thus, when he says that prejudice "has not been universal, in the sense that all cultures or all people have displayed it", the absence of supporting examples tempts disbelief. When he adds that "there is no example of a whole people advancing themselves or their civilization on the basis of it", one is inclined, while making full allowance for the degenerative effects of slavery and xenophobia, to provide him with the examples he has missed.

Another illustration of historical *naïveté* is his classification of intergroup tensions into three distinct types. "One is political in motive" and is "based on a struggle for power"—a popular cliché concealing a complex of economic motivations. The others arise more mysteriously from religious differences and racism, the latter being "largely a modern phenomenon . . . rare until its modern development less than two centuries ago as a perversion of early biological science . . .". Actually, it is an elementary historical fact that all the great religious conflicts have been essentially political, while racism is an ancient phenomenon associated with the structure of the State. Even the new racism goes back to the transformation of mercantile adventures into regular overseas trade towards the end of the sixteenth century; and it has no causative connexion with biology, though it found a rationale in the prevailing (not the perverted) biological thought of the nineteenth century. Therefore, to say that racism is "an independent cause of prejudice today" is to put the cart well before the horse.

Dr. Rose is equally original in other directions. Ignorance, he says, of the costs of prejudice to the prejudiced themselves is a "contributory root" of prejudice, which is a distorted way of saying that such ignorance is a factor assisting the maintenance of prejudice. Nor is his accounting of the financial cost impressive outside the genialities of American business. It is true that prejudice affects man-power efficiency and aggravates social problems, but it is equally true that: (1) no economic system supports situations evidently hostile to itself; (2) the losses caused by the prejudices of a ruling group are slight compared with its gains; and (3) every reduction in prejudice must substantially increase the cost of social reforms. In other words, the appeal to profit is manifestly absurd in a society where the makers of profit know a good deal more about it than Dr. Rose.

To swell the appeal with idle, if unintentionally revealing, speculations is no more than a further invitation to surgery. Perhaps it can be allowed, very doubtfully, that it "is probable that in the long run imperialistic countries could have gained even greater economic advantages if they had not employed prejudice, discrimination and violence"; but in that case they would have ceased to be imperialistic. For no imperial nation has ever been able to maintain its rule without prejudice, and every imperialism has begun to decline the moment it has been compelled to relax its prejudices to the point of admitting selected 'natives' to its own educational resources, culture and social opportunities. A benignly unprejudiced imperialism would be a historical anachronism.

The final judgment on "The Roots of Prejudice" must be that it tells us little about prejudice and less about its roots. It is written by an ideologue, whose excursions in search of originality and moral purpose merely produce over-simplifications that conceal or twist historical truths in accordance with a false empiricism. But Dr. Rose should not be blamed. He is a product, like prejudice, of circumstances, including the complications of academic sterility analysed by Veblen and Robert Lynd.

Unfortunately, the same tolerance cannot reasonably be extended to Unesco. Its policy on intergroup tensions, despite many good results, lacks co-ordinated vision. Consequently, its expensive propaganda is often unscientific, contradictory and confusing—a regrettable situation which is not likely to improve until it is realized that the reduction of "race problems" is beyond the reach of anti-racial journalese. Dr. Klineberg's advantage in providing an instructive exception lies in long personal experience of a subject that has matured; and if Unesco's other humanistic concerns were entrusted to authorities of like stature they would benefit accordingly. Moreover, critical direction would include the promotion of basic studies on those aspects of "the race question in modern science" that are modern enough but not yet scientific. The alternative is to become an advertising agency for dubious scholarship and apparently good intentions. CEDRIC DOVER

EFFECTS OF DDT UPON DIFFERENT SPECIES OF MOSQUITOES IN MALAYA

By J. A. REID

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THE reactions of *Anopheles maculatus* to DDT in window-trap huts have been shown to be very different from those of *Culex fatigans*[1,2]. With a dose of 200 mgm. DDT per sq. ft. as a wettable powder, it is nearly six months before the mortality of *Anopheles maculatus* drops below 50 per cent. The same dose, even when fresh, scarcely kills any *Culex fatigans*, although for six months it drives them out of the hut into the window-trap, and prevents many from biting.

More recently, experiments with window-trap huts and DDT have been extended to other important Malayan species, vectors of malaria or filariasis. The results during the first six to nine weeks after treatment (see table) indicate a wide range of susceptibility to DDT, as if there is almost a complete reaction spectrum, with very susceptible species such as *A. maculatus* at one end, and the least susceptible such as *Culex fatigans* at the other. The terms 'susceptible' and 'insusceptible' are preferred to 'non-resistant' and 'resistant'. The latter is commonly used to describe strains of house-flies which are not killed by direct application or even injection of DDT. But if a species of mosquito escapes unharmed from a hut treated with DDT, this may be due to

Mortality of Mosquitoes Captured in Window-trap Huts, during Six to Nine Weeks after Treatment with DDT at 200 mgm. per sq. ft. as a 25 per cent Wettable Powder

Species	Control		DDT		Per cent mortality after 24 hr. due to DDT (corrected)
	No. caught	Per cent dead after 24 hr.	No. caught	Per cent dead after 24 hr.	
Anopheles umbrosus	34	15	107	86	84
Mansonia spp.*	288	17	233	75	70
Anopheles barbirostris†	86	23	107	70	61
Anopheles sundaicus	107	14	62	66	60
Anopheles letifer	89	19	68	44	31
Culex vishnui	149	16	175	26	12
Culex fatigans	188	11	1,532	12	1

* About 80 per cent were *M. longipalpis*, the remainder mostly *M. uniformis* and *annulatus*.
† The 'dark-winged' form which is a vector of malaria.

some aspect of behaviour which prevents, or allows only a very brief, contact with the treated surfaces, rather than to innate resistance. *Anopheles gambiæ* is killed by five seconds contact with DDT in the laboratory[3], but may escape unharmed from a treated hut[4].

The results with *Anopheles umbrosus* and the vectors of filariasis in Malaya (*Mansonia* spp.) are encouraging, but we need to know how long this dose of DDT remains effective against them. Any period less than three months would probably be uneconomic. The results against *A. barbirostris* and *A. sundaicus* are not very good, and against *letifer* they are disappointing. During the first three weeks after treatment 80–100 per cent of *barbirostris* and *sundaicus* were killed, but from the fourth week onwards the mortality dropped rapidly to 50 per cent or less. With *A. letifer*, even when the DDT was fresh, the kill scarcely exceeded 50 per cent. The mortality of *A. maculatus* during 6–9 weeks after treatment has been similar to that of *umbrosus*, somewhat more than 80 per cent.

Despite this insusceptibility of some species, one might suppose that so long as DDT prevents many mosquitoes from biting it will not matter if the majority are not killed; the insecticide ought still to be effective in controlling disease transmitted by such mosquitoes. Unfortunately, except with species of *Culex*, the biting-rate is only slightly reduced. Among the anophelines (including *maculatus*) and *Mansonia* captured in the window-trap huts, the biting rate is only lowered by about 10–20 per cent after treatment with DDT. *Culex* reacts very differently, DDT reducing the biting-rate by about 70 per cent. The contrast is so marked that it probably reflects an important difference in behaviour. It seems likely that *Culex* rests on the walls before biting, and that the anophelines and *Mansonia* do not. This would agree with one's personal experience of the biting behaviour of these mosquitoes, anophelines and *Mansonia* usually attacking in a manner that is rapid and direct compared to the cautious approach of *Culex*. Wallace has shown by direct observation that *A. maculatus* entering a trap hut mostly attack immediately without first resting on the walls[5]. There is some evidence that DDT spraying directed against *Culex fatigans* can reduce the transmission of bancroftian filariasis[6], and presumably this is due to DDT preventing the mosquitoes from biting rather than killing them. But if species which are vectors of disease are not prevented from biting by DDT, the insecticide is unlikely to reduce disease transmission unless it actually kills the mosquitoes, especially if, like anophelines in Malaya, they normally leave houses to rest out of doors by day. Even with a species such as *Anopheles gambiæ* that commonly rests indoors, and is driven out of houses by DDT spraying, it appears that DDT may be ineffective unless it actually kills the mosquito. Experiments with trap huts have shown that under certain conditions DDT does not kill *A. gambiæ* nor prevent it from biting[4], and in parts of East Africa four years of DDT spraying of houses has had very little effect on malaria transmitted by *A. gambiæ*[7]. BHC, however, killed *A. gambiæ* in trap huts and has reduced malaria in the house-spraying experiments. BHC also kills all Malayan species of mosquitoes that have been tested, including those mentioned in the table. But, except for *A. maculatus* and *C. fatigans*, we do not yet know how long the BHC continues to kill. A dose of 40 mgm. per sq. ft. of gamma BHC lasts as long against *A. maculatus* as the 200 mgm. dose of DDT, that is, about six months; but after five to seven weeks it kills fewer than 50 per cent of *C. fatigans*, and has lost all effect against this species after about nine weeks[2].

Nair[8], working in Malaya under the rather difficult conditions that existed in 1945–46, made a three months trial of house-spraying with DDT in kerosene in an area where *A. letifer* was presumed to be the vector. He considers that DDT can control malaria transmission by *A. letifer*, but in view of the results presented here a further trial appears necessary.

A recent report by Hadaway and Barlow[9] suggests that failure of DDT against *A. gambiæ* may be due, at least in part, to its adsorption into the mud walls of the sprayed houses and experimental huts. BHC is also adsorbed in this way, so that no crystals remain on the surface; but it continues to kill by virtue of its fumigant action. This interesting discovery may possibly help to explain some of the contradictory reports about DDT and *A. gambiæ*; for although Muirhead Thomson's experiments with trap huts showed DDT to be ineffective[4], other workers have obtained rather different results. Differences in the DDT formulations used, as well as in the construction of the trap huts, may also have been important. No such explanation is possible for the Malayan figures presented here, for the various species were exposed to uniform conditions, and often were caught in the same hut at the same time; for example, *A. umbrosus*, *letifer* and *Mansonia*, or *A. barbirostris*, *Mansonia* and *Culex*. The huts were of almost uniform design and all were lined throughout with a brown packing-paper called 'Sisalkraft'. We must believe, then, that there are real differences among species of *Anopheles* in susceptibility to DDT when applied as a residual spray in houses, though whether due to differences of behaviour or physiology we do not yet know.

It seems most desirable that tests with window-trap huts should form part of any scheme for malaria control by house spraying with residual insecticides. Admittedly the technique is not simple; the huts can be troublesome to operate and lengthy tests are necessary, but such huts appear to be the best method of finding out what we want to know, namely, the reactions of wild mosquitoes to the insecticides when applied in habitations, and the effective duration of the doses used. It is scarcely too much to say that

something of the kind is indispensable for the rational planning of spraying programmes. In view of the many factors which, it now appears, can affect the mortality-rate of the mosquitoes, for example, the insecticide, its formulation and particle size, the nature of the treated surface, the species of mosquito and its behaviour, it will be important in future to keep conditions as uniform as possible throughout an investigation and to describe these conditions fully when reporting results. It would be interesting if tests could be made in trap huts with those vectors against which DDT house-spraying has already proved effective by reducing malaria, such as *Anopheles darlingi, albimanus 'maculipennis', culicifacies* and others. Trap huts can also yield most important information on the behaviour and blood preferences of mosquitoes. The pattern of hut and method of operation used in Malaya have been described by Wharton[10]. [June 7.

[1] Wharton, R. H., and Reid, J. A., *Nature*, **165**, 28 (1950).
[2] Wharton, R. H., *Nature*, **167**, 854 (1951).
[3] Kartman, L., and da Silviera, M. M., *J. Econ. Ent.*, **39**, 356 (1946).
[4] Muirhead Thomson, R. C., *Nature*, **163**, 109 (1949).
[5] Wallace, R. B., *Med. J. Malaya*, **5**, 115 (1950).
[6] Kohler, E., Brown, H. W., and Williams, R. W., *Pub. Health Reps.*, **64**, 857 (1949).
[7] Garnham, P. C. C., *WHO/Mal/56* (Oct. 20, 1950); or in *I.A.N.S.*, **18**, 50/124, p. 130 (1950).
[8] Nair, C. P., *Nature*, **167**, 74 (1951).
[9] Hadaway, A. B., and Barlow, F., *Nature*, **167**, 854 (1951).
[10] Wharton, R. H., *Bull. Ent. Res.* (in the press).

EVALUATION OF CHEMOTHERAPEUTIC REMEDIES

THE Biological Methods Group of the Society of Public Analysts and Other Analytical Chemists held a symposium on the "Evaluation of Chemotherapeutic Substances" during October 26–27 under the chairmanship of Dr. G. M. Findlay. The chairman, in opening the discussion, emphasized the need for rapid and accurate methods of estimating the chemotherapeutic activities of the many hundreds of compounds which are now being prepared for the specific treatment of the parasitic infections of man and his domestic animals. The final and crucial tests can obviously be carried out only in man and his domestic animals; but preliminary laboratory tests are essential both for determining relative efficiency and for the accurate assay of substances already found to be effective. Improved methods are required for evaluating anthelminthics, fungicides, and compounds active against viruses.

The general problems involved in planning large-scale collaborative antibiotic assays to ensure adequate international standardization were dealt with by Dr. W. L. M. Perry. The relationship between technique and results, the 'over-accurate' assay, the homogeneity of estimates and the validity of the combination of results were discussed. At present, few laboratories use exactly the same technique for antibiotic assays. Dr. J. Ungar described the various types of *in vitro* and *in vivo* tests which must be carried out before a compound can be used in man. Acute systemic and local toxicities, as well as chronic toxicities, must be ascertained in several species of laboratory animals. The absorption and distribution in the tissues, normal and inflamed, and the mode of excretion are points of importance, as are the likelihood of sensitization and the interaction with other drugs. These remarks were illustrated by reference to 'estopen', a penicillin ester which is concentrated in the inflamed lung. Dr. J. Humphrey pointed out that, apart from good experimental design, the most important aim in assay methods involving diffusion of antibiotics into seeded agar plates is to obtain a sharp edge to the inhibition zones and a good slope. Penicillin and streptomycin give sharp edges with suitable organisms, due probably to the uptake or destruction of these antibiotics near the zone edge giving a steep concentration gradient. With the newer antibiotics the zones are less sharp. The factors determining slope are largely physical. Prof. J. M. Robson described the use of the rabbit's and mouse's eye for determining anti-tuberculous action: one great advantage is the safety of the method for all those performing the experiments. Dr. A. R. Martin discussed very fully the methods used in employing mice for screening anti-tuberculous compounds. The relation of the chick embryo test to the mouse test was described. Miss L. Dickinson gave details of anti-viral tests carried out in the developing chick embryo and in mice. Comparable results have been obtained in mice and chick embryos with the Nigg pneumonitis virus.

Dr. L. G. Goodwin described the use of weanling rats for the evaluation of amœbicidal drugs. His remarks were illustrated by a coloured film. The use of the infected rat provides a method which fulfils the essentials for a satisfactory amœbicidal test, for the infection is reproducible without fail, and untreated controls show a constant lesion; known remedies for the disease in man show a recognizable effect; the test takes only a short time and the infecting agent is derived from man and produces the same type of lesion in the rat. The only difficulty in the use of the rat is the presence of an amœba, *Entamœba muris*, which is not affected by amœbicidal drugs. Special precautions must be taken to prevent infection of the rat colony with *E. muris*.

Dr. J. D. Fulton reported on the various media used for the growth of pathogenic amœbæ *in vitro* and their possibilities for providing methods for testing amœbicidal drugs. The question was discussed whether these amœbicidal drugs act directly on the amœbæ or indirectly on the bacterial flora which provides the pabulum for the amœbæ. The possibility of using *Trypanosoma cruzi* in place of bacteria for the nutrition of the amœbæ was described. Dr. E. M. Lourie pointed out that refined statistical methods are invaluable for biological standardization, but in the search for new compounds of value clinically they are useless if inappropriate experimental procedures are used. In Africa, in the control of trypanosomiasis, mass treatment is giving way to mass chemoprophylaxis, and new compounds are being devised for this purpose. There is therefore urgent need for a simple and rapid method for screening compounds in regard to their prophylactic activity. There is difficulty in standardizing trypanocides of the melaminyl series by chemical or physical means. Standard preparations of these substances are required, and batches intended for use in man should be biologically tested in relation to these standards.

The various laboratory tests, with monkeys, birds and mice, employed for the evaluation of anti-malarial compounds, were described by Dr. D. G. Davey. Regard must be had for the fact that, except

possibly in the case of *Plasmodium malariæ*, none of the malarial parasites in man has been established in laboratory animals. The tests used, nevertheless, are unlikely to pass over any compound of potential value in man. Dr. Ann Bishop pointed out that quinine gives rise to little or no drug resistance, and with pamaquin only a very slight increase can be induced. Proguanil, however, readily induces resistance in *Plasmodium gallinaceum*; strains treated with sulphadiazine or sulphanilamide become resistant to themselves and to proguanil. Metachloridine also induces a high degree of drug resistance in malarial parasites. In testing for ability to produce drug resistance, experimental strains of the parasite must be maintained in a state of acute infection. Results from tests upon latent infections are not comparable and are difficult to evaluate.

Dr. F. Hawking urged that when a compound has once been shown to be effective in the laboratory, it should be tested as soon as possible in man in order to bring to light toxic reactions which cannot be elicited in laboratory animals.

IMPORTANCE OF SCIENCE IN AMERICAN EDUCATION

IN a paper contributed to *Science* (113, 2945; June 8, 1951) Ernst A. Hauser, of the Massachusetts Institute of Technology and the Worcester Polytechnic Institute, suggests that most of the advances in science in pure or fundamental research have been made by citizens of countries other than the United States or by American citizens who have received their education in Europe or by Europeans who have emigrated to the United States. In a supporting statement, Hauser quotes the president of the American Society of Mechanical Engineers, who recently declared that the American failure to recognize and respond to their particular responsibilities as citizens and human beings and their failure to understand that technical progress is not enough is the key to many of the greatest difficulties in America to-day. Recently, the United States Commissioner of Education has also directed attention to the fact that a great number of educational institutions still organize their curricula in watertight compartments, and that all efforts to penetrate the barriers between departments are jealously resisted.

In an attempt to discover the weaknesses in the science side of American education, Hauser compares a German and an American university. In the latter the student is permitted to devote himself to a specialized branch of science or technology far too early, so that the last college years are used as preparation for an advanced specialized education, thereby cutting down the time that should be devoted to general education. Another essential difference between American training technique and that used in Europe is that Americans use systematic drilling as a method of instruction; this can provide sound knowledge, but is scarcely likely to promote self-reliant thinking and the spirit of research. The excessive use of the text-book may also be criticized because it works in the same direction. Throughout most of Europe only those who have graduated from the *Gymnasium* or *Realschule* may enrol in a university or comparable technological institute. When graduating from one of these schools, which they have had to attend for eight years (having left the grammar school at about ten or eleven), students have acquired a background of general education at least comparable to that of American students starting the junior year in college.

Hauser suggests that what is needed in American education is to offer all students a more general appreciation of what science actually stands for. With J. B. Conant he agrees that the objective should be to give a greater degree of understanding of science by the close study of a relatively few historical examples of the development of science. Case-histories, he suggests, would almost all be chosen from the early days in the evolution of the modern discipline, as, for example, certain aspects of chemistry in the eighteenth and nineteenth centuries. The advantages of this method of approach are two-fold: first, relatively little factual knowledge is required either of the science in question or other sciences, and relatively little mathematics; second, in the early days one sees in clearest light the necessary fumblings of even intellectual giants when they were also pioneers; one comes to understand what science is by seeing how difficult it is in fact to carry out pretentious scientific precepts.

Hauser also concurs with I. B. Cohen, of Harvard, who quite recently said that students could be given a general appreciation of what science stands for by making them more familiar with the human side of those to whom we owe the greatest discoveries in science, and with the circumstances that led to the accomplishments for which they are now famous.

CURRENT TRENDS IN GENERAL PSYCHOLOGY

THE programme for the morning session on August 9 of Section J (Psychology) of the British Association consisted of three papers discussing tendencies in general psychology. The discussion presents certain difficulties to anyone attempting to summarize it, in that the three papers were diverse in content. Prof. R. C. Oldfield was concerned with experiment in psychology; Prof. A. Rex Knight and Mr. A. J. Laird with motivation; while the present writer dealt with the teaching of psychology. Instead of a summary, therefore, an attempt will be made to discuss rather generally certain tendencies in present-day psychology which the papers seemed to reveal.

It is clear that, by the middle of the present century, psychology has outgrown certain early phases. These phases were first of all the period of the 'schools', when psychologists carried on the disputative traditions of their philosophical predecessors. There followed a phase of rather indiscriminate experimentation which was corrected after a time by a preoccupation with problems of method. More recently there has been a tendency for those interested in theory and experiment to dissociate themselves from the testers and statisticians, on one hand, and the clinicians, on the other. To-day, however, there is a considerable measure of unity, and experimental techniques are being used which are varied and flexible enough to cope with a wide range of problems.

Prof. Oldfield mentioned two investigations which show the present-day trend. In the first, attempts are being made to use rather complicated mathematical tools in describing the behaviour of a maze-running animal at a point of choice; and in the second, an analysis is being made, again using quite advanced mathematics, of certain visual illusions first investigated by Ames in the United States. Both these investigations are of great theoretical interest in themselves. But in addition, as Prof. Oldfield pointed out, they throw light on human behaviour in its everyday setting or in the clinic.

Prof. Knight and Mr. Laird were concerned to show that some rather naïve methodological assumptions about human motivation have led to logical difficulties. They suggested other interpretative schemes free from these difficulties. Again, it was emphasized that theoretical considerations of this kind are directly related to practical and clinical problems.

Finally, the present writer pointed out the increasing demand for professional psychologists and the inadequacy of present training methods in Great Britain to meet that demand. He suggested that the most useful development would consist in the expansion of training at the graduate level. It was agreed, however, that professional training should not be allowed to develop at the expense of fundamental research, nor should it be dissociated from the consideration of theoretical problems. Recent developments suggest that a good deal of research which has itself no directly practical aim will be of relevance in the practical field.

So far as any trend in general psychology was revealed by the three papers, it was this: that the different schools and aims and methodologies of psychology are disappearing, and the field is becoming much more unitary than was the case during the first part of the present century. J. DREVER

BRITISH MEDICINE AND THE CONTINENT, 1600–1850

A NEW exhibition at the Wellcome Historical Medical Museum—"British Medicine and the Continent, 1600–1850"—presents some interesting contrasts with the "Medicine in 1850" exhibition which it has replaced. The latter exhibition dealt with the medicine of Europe during a limited period, and was, in effect, a cross-section of medical thought. The new exhibition is designed to illustrate not so much the state of medicine at various times in different countries, as the fluctuating influence which the medical and scientific thought of the European Continent exercised on British medicine at different times, and *vice versa*.

A limited aspect of this approach was well brought out by Prof. Edvard Gotfredsen, professor of the history of medicine in the University of Copenhagen, in his address at the official opening of the exhibition, which took place before a distinguished company on October 19. Prof. Gotfredsen chose to deal with the relations between British and Danish medicine in the seventeenth and eighteenth centuries. He pointed out that in the seventeenth century medicine was very international, and that, as Latin was the international language of learning, medical students were enabled to travel all over Europe to hear famous teachers. Danish students of medicine of that time were forced to go abroad for much of their education, since a full medical education could not then be obtained at the University of Copenhagen. Of the Danish medical students who later became famous, those who visited Great Britain included Caspar Bartholin the elder, who wrote an important work on medical education and recommended foreign travel. Caspar's son Erasmus visited London and Oxford in 1647, and his brother-in-law, Olaff Worm, stayed for a year and a half in England.

The impact of Harvey's doctrine of the circulation was important in Denmark, since the new theory was introduced into that country by Thomas Bartholin, who also had considerable influence in spreading it on the Continent. The Dane, Holger Jacobæus, who later became professor of anatomy at Copenhagen, left some interesting descriptions of his life in London and Oxford. Prof. Gotfredsen also described in some detail the difficulties which arose in the Royal Society in attempts to confirm Stensen's work on the effects of ligating the descending aorta. In the first half of the eighteenth century the travels of Danish students had become less extensive, and in the second half they practically ceased. This fact was due to the improvement of facilities for clinical instruction in Copenhagen.

Prof. Gotfredsen was introduced by Dr. E. Ashworth Underwood, director of the Wellcome Historical Medical Museum, and a vote of thanks to him for his address was proposed by Sir Wilson Jameson.

The exhibition commences with the British and Continental background at the end of the sixteenth century. This extremely interesting period, which was the prologue to all that followed in the seventeenth century, was marked by the overwhelming importance of Paris, Montpellier and Padua. Of the English works of this period, mention should be made of the superb copy of the 1545 edition of the "Anatomy" of Geminus. Another rare work which is shown, and which itself had considerable influence on the Continent, was Mouffett's "Theatre of Insects", 1634. One of the rarest books shown in this exhibition is the first edition of "The byrth of mankynde"; this is the translation of the well-known book by Eucharius Roesslin. This first edition was published in 1540 and the copy shown is one of the very few perfect copies in existence.

It need scarcely be said that the section of the exhibition on Harvey contains fine first editions of his works. Harvey's influence on the medicine of the Continent is brought out by the published works of his supporters and of his opponents.

The rise of the Royal Society is shown in an interesting manner, as also are its connexions with the scientific men of the Continent. In the later sections Boerhaave and Haller are well represented by fine copies of their works and a number of relics. The influence of the Hunters dominates the second part of the period dealt with, and in this connexion many will be interested in the extra-illustrated edition of Jesse Foot's "Life of Hunter". This contains many original wash drawings which illustrate events in the life of John Hunter.

The later sections of the exhibition contain books and exhibits which are now classics of the late eighteenth and early nineteenth century developments of the sciences which form the fundamental basis of modern medicine.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

The Term 'Regular Solution'

In 1920[1] I directed attention to the fact that the solubility of solids, plotted as a logarithm of mole fraction against reciprocal temperature, gives a family of curves in the case of solutions "where no molecular changes are involved". In 1927[2] I designated such solutions as 'regular' and in 1929[3] I discussed the thermodynamic significance of this regularity, stating, in part: "From our picture of a regular solution as one in which orienting and chemical effects are absent, and in which the distribution and orientations are random, just as in an ideal solution, we may conclude that the probability of X_2 [species 2] is the same in the two solutions [ideal and actual] and, therefore, that the difference in entropy is zero. We cannot expect this conclusion to hold unless the random distribution of molecules persists. We may expect further that a small correction should be applied to take care of the change in entropy accompanying changes in volume, given by $(\partial S/\partial V)_T = (\partial P/\partial T)_V$; or we may state our principle in the following form. A regular solution is one involving no entropy change when a small amount of one of its components is transferred to it from an ideal solution of the same composition, the total volume remaining unchanged."

I referred to the possibility of expressing the partial molal enthalpy (of component 2) by the Margules series, $bx_1^2 + cx_1^3 \ldots$, but showed that the behaviour of many solutions can be adequately expressed by the first term alone. It became evident, soon after[4], that the mole fraction should be replaced by the volume fraction, and the coefficient b was evaluated in terms of the pure components.

The term 'regular solution' has now come into general use, but not always in conformity with the above definition. For example, Guggenheim[5] uses it as follows: "We now turn to a class of mixtures called *regular mixtures* or *regular solutions* defined by the properties $\log f_1 = wx^2/RT$—wherein w is not merely independent of the composition but independent of the temperature.—The name *regular solution* was first used by Hildebrand." Rushbrooke[6] writes a certain partition function and says, "A solution for which the partition function is given by equation (8) is known as a *regular solution*". Longuet-Higgins[7] states, "This theory [of regular solutions] assumes that in a liquid mixture (*a*) the molecules are arranged in a regular lattice, (*b*) that the separate liquid components have ordered structures of the same type and (*c*) that the intermolecular potential energy is the sum of contributions from nearest neighbours in the lattice, the contribution of two neighbouring molecules depending only on their chemical nature".

I cite these differences not for the purpose of asserting my rights as the inventor of the term but to urge that so useful a concept, to which a simple definite meaning was originally attached, should not be robbed of its significance by different writers redefining it each in his own way. I have no objection to a re-definition that may appear desirable in the light of present knowledge; but it should be made by general consent.

One question does arise in connexion with the original definition, wherein ideal entropy and random distribution of molecules were regarded as equivalent. We have since learned from a succession of investigators, culminating with Flory and Huggins[8], that the entropy of mixing molecular species of significantly different size, even though randomly mixed, is not the ideal entropy; therefore, we should decide whether to attach the term 'regular solution' to one or the other of these concepts. Prof. Scott and I, in our "Solubility of Nonelectrolytes" (third edition), have used it to mean ideal entropy, for example, the partial molal entropy of transfer $\bar{S}_1 - S_1^0$ from pure liquid to solution of mole fraction x_1 is $\bar{S}_1 - S_1^0 = -R\ln x_1$. This is more restricted than the other definition, but except for solutions of high polymers, it holds well enough for many purposes and permits expressing the activity coefficient in terms of the enthalpy. The Flory–Huggins equation involves certain assumptions that prevent it from being regarded as an accurate expression of the concept of complete randomness. To define the regular solution in terms of ideal entropy better fulfils the function of a useful reference state, well explained by Scatchard[9]: "... The student should be taught that thermodynamics deals with differences, that the number of differences to be considered can be reduced greatly by the use of reference states, that the magnitude of the differences can be reduced by the use of deviation functions, and that the choice of reference states and of deviation functions is entirely a matter of convenience, which should not be allowed to reduce the accuracy of any calculation ...".

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July 3.

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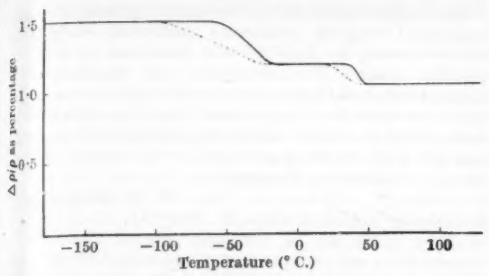
Change of Resistivity of Gold by Cold-working at Liquid-Air Temperature and its Recovery by Temporary Heating

Some time ago Molenaar and Aarts[1] observed that the increase of the resistivity of copper, silver and aluminium wires, caused by a plastic deformation at liquid-air temperature, decreased on keeping the wires at room temperature. The recovery of the resistivity was not accompanied by a recovery of the mechanical properties. The stress–strain curve at liquid-air temperature was not changed by this temporary heating.

We have now measured the recovery of the resistivity of gold wires. A gold wire, which had been soft-annealed, was stretched approximately 7 per cent at liquid-air temperature and its resistance measured. This elongation caused a relative increase of the resistivity of about 1·5 per cent. The wire was then warmed up to different temperatures, at



which it was kept for some time. After this treatment the resistance of the specimen was measured again at liquid-air temperature.

The accompanying graph shows the recovery of the resistivity as a function of the 'heating temperature'. The curve drawn is for a heating time of 2 min., while the dotted line gives the results for a heating time of 5 min. (The curves are quantitatively rather rough, as the time necessary for bringing the wire to the 'heating temperature' cannot be neglected.)

It is evident that two processes occur. At about − 50° C., the extra resistivity starts to decrease from 1·5 to about 1·2 per cent, and at about + 35° C. from 1·2 to about 1·05 per cent, when the heating time is 2 min. For a heating time of 5 min., both recovery steps start at lower temperatures.

The stress–strain curve is not changed by this heating.

As a possible explanation of these results, we suggest, following an idea of F. Seitz[2], that the extra resistivity which disappears at about + 35° C. (20° C.) is due to vacant lattice sites, while that which disappears at about − 50° C. (− 100° C.) is due to conglomerates of two or more vacant places. These vacant sites are formed during the cold-working. The absence of any change in the mechanical properties suggests that the dislocations, which are responsible for the strain-hardening, do not change at these temperatures.

We wish to thank the Delftsch Hogeschool Fonds for its financial support.

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J. A. Manintveld

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June 27.

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Elastic Constants of Alkali Halide Crystals

Adopting the simple Born model for an alkali halide crystal, in which the ions are regarded as held in their respective positions by the electrostatic and the repulsion interactions between the ions, one may readily calculate the velocities of propagation v of long acoustic waves of wave-length λ along the principal directions [100], [110] and [111], and hence along any direction, in the crystal:

$$v^2 = \sum_n (A_{1n}\Delta^2_{1n})/(m_1 + m_2), \qquad (1)$$

where m_1 and m_2 are the masses of the two ions, $2\pi\Delta_{1n}/\lambda$ denotes the difference in phase of the acoustic wave at any two ions 1 and n, and $\sum_n$ denotes summation over all the ions, except 1, in the crystal. (If D is the distance up to which the electrostatic interactions remain significant, λ is regarded as sufficiently large in comparison with D that $\cos(2\pi D/\lambda)$ can be put equal to $1 - \frac{1}{2}(2\pi D/\lambda)^2$.)

$$A_{1n} = (\psi'/R_{1n}^0)(1 - Q^2) + \psi'' Q^2, \qquad (2)$$

where $\psi(R_{1n})$ is the interaction energy between the two ions 1 and n, separated by a distance R_{1n}, and ψ' and ψ'' are its differential coefficients with respect to R_{1n} at its equilibrium value R_{1n}^0. Q is the cosine of the angle between R_{1n}^0 and the direction of displacement of the ions under the acoustic wave. Since the values of v^2 for different directions of propagation and corresponding directions of displacement are also known in terms of the elastic constants c_{11}, c_{12} and c_{44}, we obtain, by comparing them with the values obtained from (1), expressions for the elastic constants in terms of the interactions between the ions. We shall denote by ε_{11}, ε_{12}, ε_{44} the contributions to c_{11}, c_{12}, c_{44} respectively from the electrostatic interactions, which are of long range, and by ρ_{11}, ρ_{12}, ρ_{44} the contributions from repulsion interactions, which are assumed to fall exponentially with the increase in the distance of separation of the interacting ions. In view of the short range of these repulsion interactions, we regard them as confined to the immediate neighbours only.

Let us first consider a crystal of the sodium chloride type, and take the co-ordinate axes along the cubic axes of the crystal, and the origin at the equilibrium position of ion 1. It is found that the ε's and the ρ's can be expressed in terms of the following two series, in which ξ, η, ζ are integers, which, multiplied by d, the sodium–chlorine distance, define the co-ordinates of all the lattice points:

$$\Sigma(-1)^{\xi_n+\eta_n+\zeta_n}/(\xi_n^2+\eta_n^2+\zeta_n^2)^{1/2} = -\alpha, \text{ say}, \qquad (3)$$

which can be recognized as the Madelung series, and

$$\Sigma(-1)^{\xi_n+\eta_n+\zeta_n}(\xi_n^4+\eta_n^4+\zeta_n^4)/(\xi_n^2+\eta_n^2+\zeta_n^2)^{5/2} = -\chi, \text{ say}, \qquad (4)$$

which also is a known series[1]. It is further known that $\alpha = 1{\cdot}748$ and $\chi = 3{\cdot}139$. The values of the elastic constants thus calculated, which refer to very low temperatures, are given in the following table in terms of $e^2/(12d^4)$, in which e is the electronic charge. δ in the table is a number such that d/δ gives the distance over which the repulsion interaction drops to $1/e$ of its value ($\delta = 9$ in the case of sodium chloride).

	11	12	44
s	$2\alpha - 6\chi$	$-5\alpha + 3\chi$	$-\alpha + 3\chi$
ρ	$2\alpha\delta$	2α	-2α
c	$2\alpha(\delta + 1) - 6\chi$	$-3\alpha + 3\chi$	$-3\alpha + 3\chi$

Since the interaction forces have been assumed to be central, c_{12} naturally comes out equal to c_{44}, though ε_{12} and ρ_{12} are not separately equal to ε_{44} and ρ_{44} respectively. The final values for the c's are the same as those obtained by Kellermann[2] and also agree with the experimental values. Our values of ε_{12}, ε_{44} and of ρ_{12}, ρ_{44}, however, differ from his.

Similar expressions are obtained from the cæsium chloride type of crystals, in terms of two series α' and χ' that are similar to (3) and (4).

It is remarkable that for the sodium chloride type, c_{12} and c_{44}, as also the corresponding ϵ's and ρ's, depend on the lattice constant alone. This result, however, does not hold for the cæsium chloride type.

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S. K. Roy

National Physical Laboratory of India,
New Delhi. May 26.

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Calibration of Geiger-Müller Liquid Counters by the Radioactivity of Potassium-40

In recent clinical radioactive tracer studies using sodium-24, phosphorus-32 and iodine-131, it was found desirable to have a reliable and convenient radioactive standard, of similar beta- and gamma-ray energy, easily reproducible, of negligible radioactive decay and with adequate carrier protection against exchange reactions upon the glass walls of Geiger–Müller liquid counters[1]. The radioactive isotope, potassium-40 of normally occurring potassium, is present to one part in 9,000 and has a half-life of $12{\cdot}7 \pm 0{\cdot}5 \times 10^8$ years[2] with a beta-ray spectrum of maximum energy 1·38 MeV. and a gamma-ray of energy 1·5 MeV.

Some time ago, Barnes and Salley described[3] a method for the analysis of potassium by its natural radioactivity, using a Geiger–Müller liquid counter calibrated with standard potassium solutions. The time required, from statistical theory, for a measurement with probable error of $\pm$ 1 per cent for a 4 *N* potassium chloride solution in a 20-ml. counter was about 70–80 min. In my early experiments, concentrated solutions of potassium chloride were used for calibrating counters. Later it was found that concentrated solutions of potassium carbonate gave nearly three times the counting-rate of concentrated potassium chloride. The most convenient compound from the point of view of solubility and potassium concentration was found to be potassium carbonate, which at 20° C. has a solubility of 112 gm. per 100 ml. water.

A type *M*6 10-ml. Geiger–Müller liquid counter filled with standard potassium carbonate solution gives 550 counts/min. with the counter enclosed in a protective lead screen. The background count is by comparison 15 counts/min. Other solutions, of potassium bromide and iodide, have also been tried, but, owing to the lower solubility and small concentration of potassium, give lower counting-rates. Solutions of potassium hydroxide may be used to give a 20 per cent greater counting-rate than potassium carbonate, but are much less convenient in manipulation.

It is therefore suggested as a basis of international standardization of Geiger–Müller liquid counters that they may be calibrated with standard potassium carbonate solutions with an accuracy of $\pm$ 1 per cent in 8 min. counting time.

A standard solution can be made up from 100 gm. analytical reagent potassium carbonate anhydrous (after heating to 200–300° C.) dissolved in 100 ml. distilled water. The advantage over standard solutions of cobalt-60 hitherto used[4] for counter standardization is that there is low cost, and the carbonate is universally available, has negligible radioactive decay and gives no residual activity in the counter due to adequate carrier protection.

T. A. Chalmers

Radium Institute, Liverpool. July 31.

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Propagation of Very-High-Frequency Radio Waves

During the period autumn 1949 – spring 1950, a series of measurements of field-strength from a very-high-frequency airborne transmitter was made at the Royal Aircraft Establishment. The main purpose of the investigations was to examine the field-strengths obtained in varying weather conditions with one end of the propagation path at a height of 40,000 ft. above the earth (the other end being at a height of 90 ft.) and to compare them with the field-strengths calculated from conventional ray-theory for a smooth spherical earth for both ordinary and four-thirds earth radius. For this purpose the two frequencies 280·2 and 386·6 Mc./s. were chosen.

In the curves of field-strength, plotted against distance between transmitter and receiver for those cases where the indirect ray was reflected from land, the observed minima were in some cases shallower than the calculated values, as could be expected for reflexion from a rough surface, but in no case were they deeper. Fig. 1 is a typical curve for land reflexion. In all instances, however, where the indirect ray was reflected from the sea, as in Fig. 2, the observed minima were considerably deeper than the calculated values, and this feature was also present

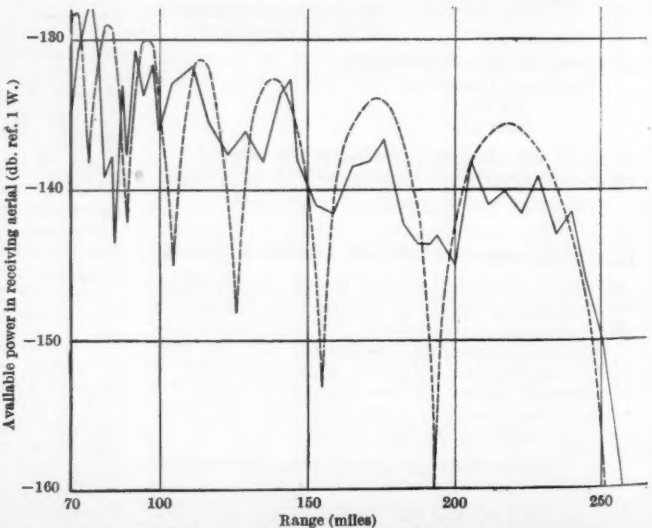

Fig. 1. 386·6 Mc./s., over land: ----, calculated; ——— measured

in two observations made with the transmitter at a height of 10,000 ft.

It was also noted that in about 90 per cent of the observations there was closer agreement between curves of observed and calculated field-strengths for both land and sea reflexion of the indirect ray, when the earth's radius was taken at its ordinary value rather than the conventional four-thirds value to allow for 'normal' atmospheric refraction.

The permittivity and conductivity of earth were taken as 10 electrostatic units and 10^{-13} electromagnetic units respectively, and, for sea, as 81 e.s.u. and $4{\cdot}6 \times 10^{-11}$ e.m.u. respectively, in the calculation of reflexion coefficients. The abnormally deep minima in the case of sea reflexion are equivalent in some cases to an apparent increase in reflexion coefficient by a factor of 2·25, and the discrepancy between observed and calculated values decreases with decrease in the angle of incidence of the indirect ray on the sea; that is, it attains a maximum value with maximum distance between transmitter and receiver.

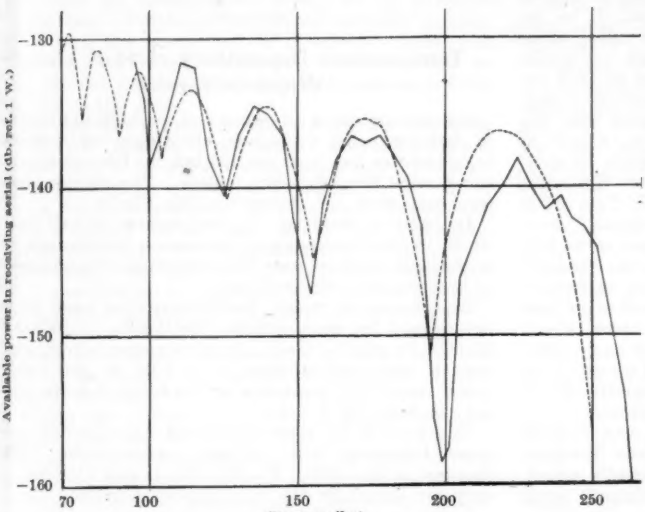

Fig. 2. 386·6 Mc./s., over sea: ----, calculated; ———, measured

The topography of the cliff site chosen for the investigations over sea was such that no reflected ray from local objects or land-masses could account for the additional energy necessary to produce the large apparent increase in reflexion coefficients; and any abnormal increase in atmospheric refraction would have tended to produce shallower minima, since angles of incidence at a given distance would have been reduced and thereby reduced the corresponding reflexion coefficients. Any inertia in the recording instruments employed would also have tended to make minima shallower.

The weather conditions during the investigations varied from settled, anticyclonic types to low-pressure, unsettled weather with considerable variation of temperature, humidity and wind.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

E. Heaton Jones

Royal Aircraft Establishment,
Farnborough, Hants. Aug. 16.

Reduction of Static Electrification by means of Inhibiting Compounds

In connexion with the problem of static electrification in the processing of nylon fibre, we have undertaken a study of the factors involved in the reduction of static charges by means of 'antistatic agents'.

The work of Coehn[1] and Richards[2], coupled with that of Gill and Alfrey[3], indicates that such electrical charges are generated by the the transfer of electricity between two bodies of different dielectric constant, induced by a natural field which sets up a contact potential at the interface when the bodies are brought into contact. The transfer takes place in a direction such that the contact potential is neutralized, and the charges become evident only on subsequent separation of the two bodies. The high voltages encountered are due to the drop in capacity of the system on separation of the bodies according to the well-known law, the charge actually remaining the same as when they were in contact.

An apparatus was constructed which gave reasonably quantitative measurements of the electrostatic effect of rubbing nylon yarn against a metal surface. A 2-gm. hank of nylon was rubbed back and forth over three metallic rods by means of an eccentric revolving at 60 r.p.m. The outer rods were of steel and connected to earth. The central rod was of brass and connected to one terminal of a voltage-measuring device, the other terminal of which was earthed. The relative humidity of the surrounding atmosphere was controlled to 29 ± 1 per cent. In operation the voltage was read after 60 strokes of the hank. Under controlled conditions, voltage measurements were consistent within 2 per cent. The earthed steel rods contributed considerably to the reproducibility of the results. They appeared to restore the nylon to a standard electrical state after each passage over the brass rod.

Figs. 1 and 2 show the results obtained for five liquids when applied to nylon in increasing amounts. When a new liquid was to be tested the rods were cleaned with acetone. Two types of curve will be noted. The smooth curves in Fig. 1 show a variation with the dielectric constant (D). The liquid having the higher constant seems to be the more effective at small amounts on the yarn in reducing the genera-

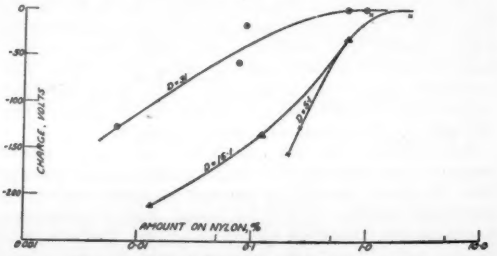

Fig. 1. Effect of dielectric constant D on charge

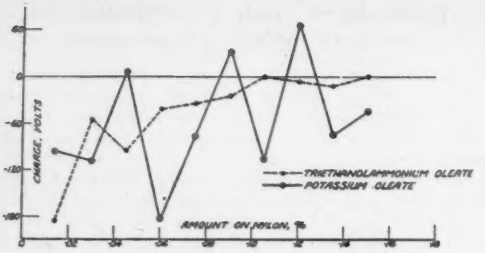

Fig. 2. Effect of surface activity on charge

tion of electrical charges. It may be that water owes its effectiveness for this purpose to the comparatively high dielectric constant ($D = 81 \cdot 5$). Liquids of the surface-active type appear to give a second class of curve. Two examples, chosen from a large number, are illustrated in Fig. 2. These curves follow the general trend of those of the first class, but show a peculiar periodicity, often with a reversal of sign of the electrical charge. This would seem to be an expression of the existence of molecular layers, since the change in amount of liquid between the peaks and valleys on the curve approximates to that required to deposit a monomolecular layer on the nylon. From the reversals in sign it would seem that the dipoles are oriented alternately in direction. Electrical charge is finally eliminated when the layer of antistatic agent is sufficiently thick to allow the outer surface to behave as an isotropic liquid. This effect is illustrated by triethanolammonium oleate. Potassium oleate, on the other hand, appears to be laid down in much more rigid layers and, in the example given, is not present in sufficient quantity to behave as an isotropic liquid. The most effective of this class of antistatic agent seem to be those which combine (*a*) a dipole of such a strength as to limit the field due to the nylon within several layers of the surface, and (*b*) a degree of surface activity which allows random orientation at small amounts.

The experimental results allow us to speculate on the mechanism by which antistatic agents function. If a body, covered by a film of antistatic agent, meets a second body, a thin film of antistatic agent separates the two. The antistatic agent limits the fields of the bodies to a short distance within the film, so that interaction of the fields is impossible and no contact potential is created within the body of the film. If, on subsequent separation, the division takes place within this section of the film, then no significant static charge results since, in effect, like materials have been separated. The more effective the antistatic agent is in limiting the field the more effective it is in reducing static charges.

Examination of the curve for potassium oleate seems to give information on the mechanism of generation of static electricity as well as that concerning antistatic action. It will be noted that considerable voltages are indicated at points where the influence of the nylon must be comparatively small. These voltages seem to be due to dipoles fixed in position by orientation with the nylon acting as a support only. Therefore, one might conclude that one type of generation of static electricity, at least, is due to the action of dipoles in fixed orientation at or near the interface of bodies in contact.

The advice and criticism of Dr. J. H. Michell is gratefully acknowledged. We are indebted to Canadian Industries, Ltd., for permission to publish this communication. A detailed account of the work will be published elsewhere.

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June 18.

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Temperature Dependency of Half Line-Width in Ferrite

An experimental investigation of half line-width in ferromagnetic resonance absorption at various temperatures has been carried out by Bloembergen[1], using some ferromagnetic metals. The results were compared with the theory by Van Vleck[2].

In order to clear up the real nature of half line-width in the ferromagnetic resonance experiment, it is desirable to investigate the temperature dependency of line shape in an insulator.

In the present work, half line-widths have been determined for some ferrites, $MgOFe_2O_3$, $CuOFe_2O_3$, $MnOFe_2O_3$ and $NiOFe_2O_3$, in a resonance experiment over a temperature-range of $-195°$ to the Curie point, using thin specimens in the form of disks, and a wave-length of 3·2 cm.

The results for these materials show almost the same tendency with varying temperature; the changes of line-width for $MgOFe_2O_3$ and $CuOFe_2O_3$ only are shown in the accompanying tables.

$MgOFe_2O_3$. Curie point, 432° C.

Temp. °C.	−190	−130	−110	−82	−50	16	51	79	124	164	204	242	281	320	356	390	398
Line-width (Oe.)	840	680	640	588	502	435	388	338	316	270	240	200	160	157	116	98	97

$CuOFe_2O_3$. Curie point, 430° C.

Temp. °C.	−176	−145	−122	−99	−87	−65	−50	−20	20	62	102	110	147	210	260	310	362	400	410
Line-width (Oe.)	800	700	609	550	520	482	465	420	350	315	258	265	240	200	190	170	137	122	122

Generally speaking, the half line-width decreases monotonously with increase of temperature; the line-width becomes narrower at temperatures near the Curie point; afterwards the resonance suddenly disappears above the Curie point. The results are quite contrary to the case of ferromagnetic metals.

Details of the apparatus and procedure will be published in *Sci. Rep. RITU*.

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Hüttig's Adsorption Isotherm

THREE years ago, Hüttig[1] derived a multilayer adsorption isotherm which in most cases agrees with experiment up to higher relative pressures $x = p/p_0$ (where p_0 is vapour pressure of the liquid adsorbate) than the Brunauer–Emmett–Teller[2] isotherm. Hüttig's formula, however, is not in accord with the kinetic assumptions implied in the derivation and does not explain the entire failure of the theory at very high pressures (x greater than 0·8).

The kinetic assumption underlying Hüttig's theory is that *all* molecules of each layer may evaporate, whereas in the Brunauer–Emmett–Teller theory only uncovered molecules are allowed to do so. Hüttig's mechanism of desorption is rather unrealistic from the point of view of the multilayer model in which the adsorbed molecules are arranged in vertical chains. To permit a lateral evaporation of covered molecules, these vertical chains must be arranged rather loosely, and one can scarcely assume that such an arrangement would be in a stable equilibrium. Further, if a covered molecule evaporated from the lower part of a vertical chain, this chain would collapse or at least re-arrange itself, so that the net result would again be evaporation from the top of the chain.

This difficulty can be removed in the following way. We consider a surface on which adsorption occurs only at localized centres separated from each other by surface regions with negligible attractive power for the adsorbate. The distance between the centres should be at least one or two molecular diameters. Then the vertical chains of the multilayer model turn over into the surface, where they form essentially two-dimensional clusters around the localized centres. In this model the concept of several layers loses its meaning. We can distinguish only between the molecules adsorbed on the localized centres (first layer) and additional molecules (higher layers). We shall, however, retain Hüttig's formalism in which the different layers are distinguished. It appears that for this model Hüttig's mechanism of evaporation is quite satisfactory. A proof of this assumption can be derived, however, only from a rigorous statistical treatment of the model. The statistical equivalent to Hüttig's formalism will be investigated elsewhere.

Quite independent of the special condition of desorption, there is still another, much more general, argument for the proposed cluster model. It has been shown by Halsey[3] that two-dimensional condensation within the first layer occurs earlier than the formation of higher layers in all cases where the surface centres are close enough together to exclude the cluster model suggested here. Hence it appears that this latter model is the only one which fits the formalism of Brunauer–Emmett–Teller or Hüttig.

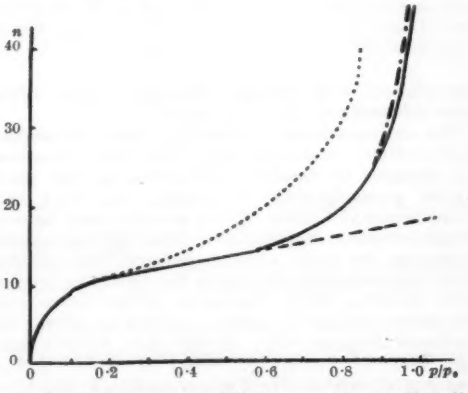
Concerning the failure of Hüttig's isotherm for very high pressures, we assume that this failure is the result of the simplification that the affinity constants K_1 and K (see equation 1) or, in other words, the conditions of evaporation, do not depend on the number of adsorbed molecules. This simplifying assumption can be modified in a semi-empirical way by the following considerations. The clusters, which are essentially two-dimensional at low pressures, will gradually overlap and grow vertically to the surface if the pressure is increased. The result will be that a certain fraction n' of the n adsorbed molecules will be entirely enveloped by other molecules, and hence unable to evaporate. If we put $n' = nx^s$, Hüttig's velocity of desorption $K_i''n$ is transformed to $K_i''n(1 - x^s)$ and the affinity constant $K_i = K_i'/K_i''$ is transformed to $K_i/(1 - x^s)$. Introducing this expression into Hüttig's formula (1) (where n_0 is number of surface centres),

$$\Theta = \frac{n}{n_0} = \frac{K_1 p}{1 + K_1 p}\,(1 + Kp)\,; \qquad (1)$$

and putting $K_1 p = Cx$ and $Kp = x$, we obtain:

$$\Theta = \frac{Cx}{1 + Cx - x^s} \cdot \frac{1 + x - x^s}{1 - x^s}. \qquad (2)$$

Equation 2 is the formula for the cluster isotherm in the notation of the Brunauer–Emmett–Teller theory. It is a generalization of formulæ which are the limiting cases for $s = 1$ (Brunauer–Emmett–Teller) and $s = \infty$ (Hüttig). Since in Hüttig's theory the number of chains containing s adsorbed molecules is about $n_1 x^s$ (n_1 is number of molecules in the first layer), s can be interpreted as the average number of molecules necessary to envelop entirely a molecule of the first layer. Hence the reciprocal of s measures the tendency of the essentially two-dimensional clusters partly to grow vertically to the surface. $1/s$ is zero for Hüttig's isotherm; this involves restriction to entirely two-dimensional clusters and the finite number $2n_0$ of adsorbed molecules for $p = p_0$.



——, Experimental; – – – –, Hüttig; . . . . . , Brunauer–Emmett–Teller; — · — · —, cluster-isotherm

Adsorption isotherms for the system H_2O–$BaSO_4$ at 273° K.

The agreement between formula (2) and experiment is found to be very satisfactory. This can be seen from the accompanying graph, which is characteristic of a large number of cases. The parameter s, which is 5 in this case, has been found to assume values between 2 and 12 in other systems and to increase with temperature.

Details of this work will be published elsewhere.

OTTO THEIMER

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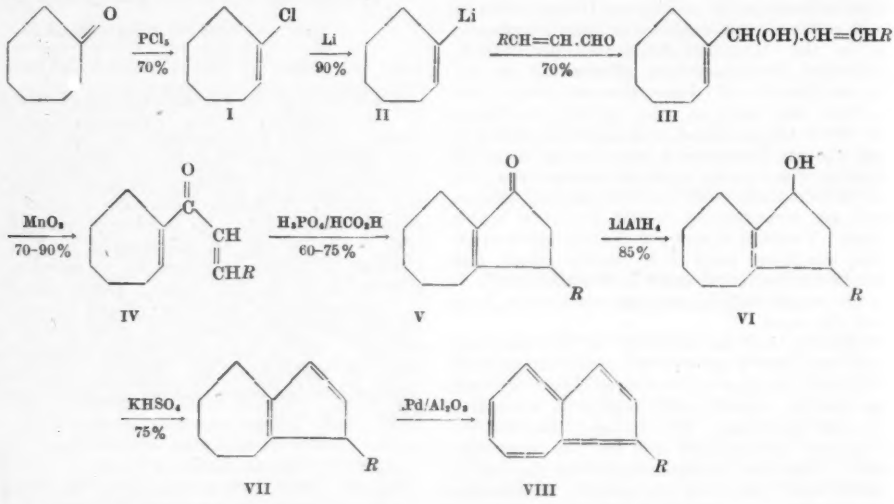
A New Route to Azulenes

Although several syntheses of azulene (VIII; R=H) and azulene derivatives have deen described[1], investigations on the chemistry of this non-benzenoid aromatic system have been hampered by the fact that the procedures hitherto available do not readily lend themselves to the preparation of azulenes on more than a relatively small scale. We have recently developed a new synthesis, based on the method of alkenylation with lithium alkenyls[2], which offers some advantages in this respect.



The new synthesis is illustrated here for azulene itself and for 1-methylazulene. 1-Chloro*cyclo*heptene (I), prepared by treating *cyclo*heptanone with phosphorus pentachloride[3], is readily converted into 1-*cyclo*heptenyl lithium (II) by reaction with lithium metal in ether suspension[4]. The lithium alkenyl undergoes the usual addition reaction with acraldehyde or crotonaldehyde, to give the dialkenylcarbinols (III; R=H or Me)[4]. Oxidation of the latter with manganese dioxide in petrol suspension[5] affords the dialkenyl ketones (IV; R=H) (b.p. 61°/0·5 mm., n_D^{21} 1·5138; found: C, 80·4; H, 9·7; $C_{10}H_{14}O$ requires C, 80·0; H, 9·4 per cent), 2 : 4-dinitrophenylhydrazone (m.p. 198°), and (IV, R=Me) (b.p. 84°/0·4 mm., n_D^{25} 1·5166; found: C, 80·6; H, 10·1; $C_{11}H_{16}O$ requires C, 80·4; H, 9·8 per cent), 2 : 4-dinitrophenylhydrazone (α-form, m.p. 118°; β-form, m.p. 129°). Treatment of the ketones (IV) with a mixture of phosphoric and formic acids[6] at 90° resulted in smooth cyclization to the octahydroketoazulenes (V, R=H), $\lambda_{max.}$ 2410 (ε 12,300) and 2910 A. (ε 85) in ethanol; semicarbazone, m.p. 238° (reported[7,8] m.p. 238° and 235–236°) and (V, R=Me) (b.p. 77°/0·4 mm.; n_D^{22} 1·5118; $\lambda_{max.}$ 2440 (ε 9200) and 3000 A. (ε 65) in ethanol; found: C, 80·4; H, 9·8; $C_{11}H_{16}O$ requires C, 80·4; H, 9·8 per cent), 2 : 4-dinitrophenylhydrazone (m.p. 236°). Reduction of the octahydroketoazulenes with lithium aluminium hydride in ether at 0° gave the hydroxyoctahydroazulenes (VI, R=H) (b.p. 64°/0·1 mm., n_D^{20} 1·5132; found: C, 79·1; H, 10·9; $C_{10}H_{16}O$ requires C, 78·9; H, 10·6 per cent) and (VI, R=Me) (b.p. 80°/0·4 mm., n_D^{21} 1·5058; found: C, 79·5; H, 10·9; $C_{11}H_{18}O$ requires C, 79·5; H, 10·8 per cent), 3 : 5-dinitrobenzoate (m.p. 87°). Dehydration of the alcohols (VI) by distillation from potassium bisulphate and dehydrogenation of the resulting dienes (VII) with a palladium–alumina catalyst[9] afforded azulene (VIII, R=H) and 1-methylazulene (VIII, R=Me). The latter gave an *s*-trinitrobenzene adduct (m.p. 155°, undepressed on admixture with an authentic specimen kindly provided by Prof. Pl. A. Plattner[7]).

Other methods of effecting the last step are under investigation, and details of this work will be published elsewhere in due course.

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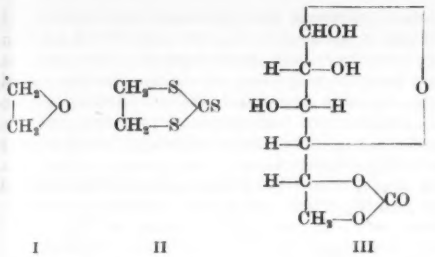
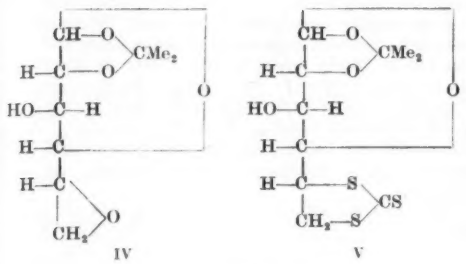
Some Trithiocarbonate Derivatives of Carbohydrates

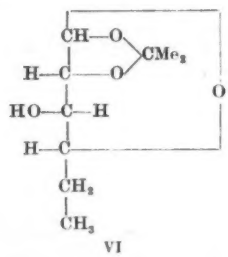
Ethylene oxide (I) and its simple analogues react with carbon disulphide and potassium hydroxide in methyl alcoholic solution to give cyclic compounds, containing three atoms of sulphur, which are termed trithiocarbonates. Culvenor, Davies and Pausacker[1] described the transformation of ethylene oxide into ethylene trithiocarbonate (II), and of *cyclo*hexene oxide into *cyclo*hexene trithiocarbonate. Furthermore, although this transformation has not yet been carried out, these compounds should readily undergo reductive desulphurization



I II III



IV V



VI

with Raney nickel, according to the method of Bougault, Cattelain and Chabrier[2], and afford ethane and *cyclo*hexane. It occurred to us that the exploitation of these two reactions in the carbohydrate series might lead to a method of introducing two vicinal deoxy groups into sugar molecules, which might be of value considering the importance now assumed by deoxysugars in modern carbohydrate chemistry.

Sugar carbonates are already well known and possess properties which make them particularly useful in synthetic work, because the carbonate group is stable to mildly acidic conditions but labile to alkaline reagents. Haworth and Porter[3] prepared glucofuranose 5 : 6-carbonate (III) in 1929 and used it to prepare crystalline glucofuranoside derivatives. It is anticipated that trithiocarbonates may also find uses in synthetic sugar chemistry, not only as protective groups but also as a means whereby thiol groups may be introduced into sugar molecules.

We have now found that three ethylene oxide derivatives of carbohydrates readily yield trithiocarbonate derivatives, and that these undergo smooth reductive desulphurization to furnish the corresponding dideoxy compounds.

1 : 2-*iso*Propylidene 5 : 6-anhydroglucofuranose (IV), on treatment with carbon disulphide and potassium hydroxide in boiling methyl alcohol, furnished 1 : 2-*iso*propylidene 5 : 6-dideoxyglucofuranose trithiocarbonate (V), melting point 179·5–180·5° (found : C, 40·8; H, 4·52; S, 32·3; $C_{10}H_{14}O_4S_3$ requires C, 40·8; H, 4·76; S, 32·6 per cent). This, on reductive desulphurization with Raney nickel in boiling ethyl alcohol, afforded 1 : 2-*iso*propylidene 5 : 6-dideoxyglucofuranose (VI), melting point 78°, $[\alpha]_D^{21}$ −31·4° (in chloroform) (found : C, 57·4; H, 8·5. $C_9H_{16}O_4$ requires C, 57·4; H, 8·5 per cent). 1 : 3-2 : 4-Diethylidene 5 : 6-anhydrosorbitol and 1 : 2-3 : 4-di-*iso*propylidene 5 : 6-anhydromannitol serve as examples of hexitol derivatives which may participate in this reaction. The sorbitol derivative gave rise to 1 : 3-2 : 4-diethylidene 5 : 6-dideoxysorbitol 5 : 6-trithiocarbonate as yellow needles of melting point 182–183·5° (found : C, 43·0; H, 5·37; S, 30·7; $C_{11}H_{16}O_4S_3$ requires C, 42·8; H, 5·2; S, 31·2 per cent), which was smoothly transformed, by treatment with Raney nickel, into 1 : 3-2 : 4-diethylidene 5 : 6-dideoxysorbitol, melting point 84·5–85·5°. This was clearly identical with the compound, melting point 85–86°, prepared by Bladon and Owen[4], by the treatment of 5 : 6-ditoluene-*p*-sulphonyl 1 : 3-2 : 4-diethylidene sorbitol with sodium iodide followed by hydrogenation of the corresponding 5 : 6-sorbitoleen produced. The mannitol anhydride afforded 1 : 2-3 : 4-di-*iso*propylidene 5 : 6-dideoxymannitol 5 : 6-trithiocarbonate, melting point 95–96° (found : C, 46·5; H, 6·04; S, 28·8; $C_{13}H_{20}O_4S_3$ requires C, 46·4; H, 5·95; S, 28·6 per cent), which, on reductive desulphurization gave 1 : 2-3 : 4-di-*iso*propylidene 5 : 6-dideoxymannitol as a liquid distilling at 90° (bath temperature)/0·05 mm. and showing $[\alpha]_D^{20}$ + 11·5° (in alcohol) (found : C, 62·9; H, 9·2; $C_{12}H_{22}O_4$ requires C, 62·6; H, 9·6 per cent).

All three trithiocarbonate derivatives were beautifully crystalline solids of bright yellow colour showing a strong absorption band in the ultra-violet region of the spectrum at λ 3160 A. (ε max. 13,500–15,000).

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Tetrabromothiophene from 2-Bromothiophene by means of Sodium Acetylide in Liquid Ammonia

In the course of our investigations on acetylenic compounds in the thiophene series[1], it was desired to synthesize 2-thienylacetylene directly from 2-bromothiophene and 2-chlorothiophene by means of sodium acetylide in liquid ammonia. Although it is known that arylations via this method are unsuccessful when applied to halides in the benzene series[2a,b], no experiments are recorded in the literature with heterocyclic compounds. In view of the greater reactivity of the thiophene nucleus, it appeared worth while to attempt this reaction.

2-Bromothiophene was prepared according to an earlier description[3], the sodium acetylide by known methods[2a,b], and the 2-chlorothiophene used was a commercial product.

While 2-chlorothiophene did not react and the starting material was recovered quantitatively, 2-bromothiophene reacted vigorously. To the pre-

pared sodium acetylide in liquid ammonia the calculated amount of 2-bromothiophene was added by drops. The reaction mixture was stirred for four hours and hydrolysed with water. When sodium acetylide was prepared without using a catalyst (hydrated iron nitrate), the reaction mixture turned from colourless to light brown and finally, after hydrolysis of the mixture, to black. There was also present a large amount of free carbon. Under analogous conditions, when employing 2-chlorothiophene, no free carbon was noticed. After isolation of the reaction product with ether, there resulted a crystalline substance and we regained some starting material. From 50 gm. (0·32 mole) of 2-bromothiophene we obtained 10–14 gm. of the crystalline substance, 13 gm. (0·08 mole) of recovered 2-bromothiophene, and 2 gm. of a high-boiling oil, probably a mixture of di- and tri-bromothiophene. The yield of the crystalline substance was 35–45 per cent, depending on the method of preparation of the sodium acetylide. The yield was greater when the sodium acetylide was prepared via sodium amide using an iron nitrate catalyst.

The substance, recrystallized from dilute ethanol, gave white needles melting at 114° C. The analysis gave the following results: calculated for C_4Br_4S: C, 12·02; Br, 80·00; S, 8·04; found: C, 12·31; Br, 80·25; S, 8·44. The molecular weight determined by the Rast method was 380 ± 12. The product was identified as tetrabromothiophene, in that it did not depress the melting point on admixture with an authentic specimen prepared according to the method of Volhard and Erdmann[4].

Further investigations on this type of reaction are being carried out.

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Urea as a Solvent

Although urea is an inexpensive laboratory chemical, its solvent properties do not appear to have been fully appreciated by chemists. Nevertheless, it may well prove to be one of the most versatile solvents known. Maintained at its melting point of 132° (conveniently done, if so desired, by refluxing with xylene with which it is immiscible) its decomposition is very slow. It then combines the solvent properties of water with that of alcohols.

Of approximately a hundred and twenty common inorganic chemicals, the only water-soluble compound which could not be dissolved in urea was sodium silicate. On the other hand, iodine proved to be very soluble.

In general, ions in urea solution possess their familiar colours, save that cobalt solutions are blue. Powerful oxidizing and reducing agents are, of course, decomposed; nevertheless, alkali metal chromates, dichromates and ferricyanides are surprisingly stable, the last-named much more so than in formamide solution.

Common inorganic precipitation reactions can be carried out in urea solution; precipitates of sulphur, copper, mercury, silver, mercurous chloride, mercuric iodide, barium sulphate, thallium iodide, silver chloride, bromide and iodide, silver chromate, magnesium and barium carbonates, copper ferrocyanide, heavy-metal sulphides, nickel dimethylglyoxime, etc., were readily obtained.

Urea dissolves methyl orange, phenolphthalein and litmus readily—the colouring matter is rapidly dissolved from litmus paper, giving a blue or red solution depending upon the acidity. Sodium carbonate is easily soluble and can be titrated with such acids as sulphuric, sulphamic or oxalic. With phenolphthalein, sodium carbonate gives a deep red solution below 140°; at 150° the colour is discharged but returns reversibly on cooling. Ammonium salts of strong acids give strongly acid solutions when hot which reversibly become alkaline on cooling. Alkali hydroxides are soluble but produce carbonate fairly rapidly. Acid solutions attack metals, evolving hydrogen.

Urea proved an excellent solvent for all save a small number of common organic chemicals. Among those with low molecular weights only hydrocarbons were insoluble. Nitro, amino and carboxy groups confer increasing solubility in the order given. Hydroxy compounds, ketones, esters, anilides, amino-acids, substituted hydrazines, etc., are readily soluble and decomposition is rare. Often the organic compound is miscible with molten urea in all proportions. Gluten, dextrin, sodium alginate, gum arabic, soap, etc., dissolve readily.

In the laboratory, urea is a valuable tool for dissolving sparingly soluble compounds. (1) A 5 per cent solution of N-phenylanthranilic acid in molten urea is cooled and powdered. For use as an oxidation-reduction indicator, 0·5 gm. of the solid is added to a solution, when the urea instantly dissolves, leaving the indicator as a finely divided suspension in the liquid. (2) So-called 'soluble' starch dissolves in urea to give a highly viscous clear solution. If a 5 per cent solution is cooled and powdered, the product is ideal for use in titrations involving iodine. It dissolves almost instantly to give a clear colourless solution which is still highly sensitive to iodine, giving the familiar blue colour.

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A Rapid Method for the Determination of Nucleic Acid Components by Paper Partition Chromatography

Methods for the analysis of small amounts of nucleic acids and their components by paper partition chromatography have been described by Vischer and Chargaff[1] and Chargaff *et al.*[2]. Photographic methods for their identification on paper have also been used[3,4], based on the specific absorption in the ultra-violet range of the spectrum of the nucleic acid components. The present communication describes a simple and sensitive method for rapid analysis in routine work.

Hydrolysis. The purines, adenine and guanine, and the pyrimidine nucleotides, cytidylic acids and uridylic

acids, were obtained by acid hydrolysis of yeast nucleic acid (1 hr., 1 *N* hydrochloric acid, 100° C.).

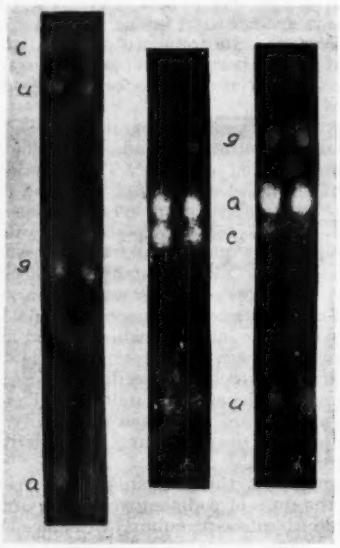
Separation. Spots containing 50–150 γ nucleic acid were prepared on filter paper (Munksell OB) by an Agla micropipette. Butanol was used as a solvent in the following two solutions: (*a*) *N*-butanol (4), dioxane (1) and distilled water (1), the spots on the paper being neutralized by gaseous ammonia; (*b*) *N*-butanol (4), diethylene glycol (1) and 1·5 *N* hydrochloric acid (1). Table 1 shows the R_F values found.

Table 1. R_F VALUES

	Solutions	
	a	*b*
Adenine	0·64	0·29
Guanine	0·37	0·18
Cytidylic acid	0·69	0·35
Uridylic acid	0·17	0·63

A suitable time for separation on paper strips 40 cm. long was found to be 18 hr. After drying the paper strips for two hours at 80–90° C., photography was carried out in the ultra-violet range.

Optical equipment. Monochromatic light of wavelength 257 μμ and 275 μμ was generated between rotating cadmium electrodes of an ultra-violet microscope constructed according to Köhler. A quartz condenser of numerical aperture 0·3 and a 6-mm. monochromat of numerical aperture 0·35 corrected for 257 μμ or 275 μμ (Cooke, Troughton and Simms) was used. 60 cm. from the exit pupil of the objective a drum was fastened to a stand, with its axis perpendicular to the incident light and within the homogeneous field of illumination. The drum is 13 cm. in diameter and 12 cm. wide, provided with a fold at the edges, and it is rotated by a crank. Paper strips 5–10 cm. wide were photographed against a blue-sensitive photographic paper of similar width. Paper and film were braced by two strips of brass, the distance between which could be varied.



(1) (2) (3)

Paper strips 5 cm. broad photographed in the ultra-violet. (1) With butanol–dioxane–distilled water as solvent at 257 μμ, (2) and (3) with butanol–diethyleneglycol–hydrochloric acid at 275 μμ and at 257 μμ. In both instances 65 γ yeast-nucleic acid was subjected to separation. *a*, *g*, *c* and *u* refer to adenine, guanine, cytidylic acid and uridylic acid respectively. Note increase in sensitivity at 275 μμ

Thus, paper up to 40 cm. in length could be photographed continuously. Uniform exposure was obtained by rotation of the drum for 60 sec. at 257 μμ and for 30 sec. at 275 μμ.

Results. Photographs of some chromatograms are reproduced in the accompanying figure. The sensitivity of the method for purines and pyrimidines in γ per cm.[3] can be seen from Table 2.

Table 2

Adenine	0·35
Guanine	0·55
Cytosine	0·75
Uracil	0·45
Thymine	0·60

By using the cadmium band at 275 μμ the value for cytosine can be halved.

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Identification of Sulphonamides on Paper Chromatograms

THE recent communication on this subject by R. Robinson[1] has prompted me to record some observations made about two years ago on this subject.

Butanol – acetic acid solvent was found the most satisfactory of many solvents tried, being prepared by mixing *n*-butanol, acetic acid and water in proportions 50–15–35 by volume. The mixture is homogeneous and very slightly under-saturated with water at room temperature, it is easily prepared and gives reproducible R_F values which are almost identical with those obtained with the equilibrated solvent suggested by Partridge in 1948.

R_F-values found range from 0·55 (sulphaguanidine) to 0·85 (sulphamerazine). Some good separations are obtained; for example, the three components of sulphatriad can be demonstrated in the urine of a patient on treatment with this drug.

Detection of the sulphonamide spots makes use of the diazo- and coupling reaction carried out in alcoholic solution to minimize spreading of the spots. Nitrous acid solution is sprayed on the dried paper, followed after one minute by a 1 per cent solution of dimethyl-α-naphthylamine or similar coupling reagent. The sulphonamides show as red or pink spots of the azo colour, one microgram being readily detected.

No spreading of the spots occurs and quantitative measurements have been carried out quite successfully using the method described by Fisher *et al.*[2].

The nitrous acid solution is prepared as follows: 0·1 gm. of sodium nitrite in 1 ml. of water is shaken with 10 ml. of *n*-butanol, and 0·3 ml. concentrated hydrochloric acid added with shaking. The mixture is allowed to stand for a few minutes before use; solid sodium chloride may separate. The solution is stable for several days.

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Phenolases in the Echinoid, *Diadema antillarum* Philippi

Diadema antillarum possesses an abundant black pigment which shows the chemical and histochemical properties of melanin, and is concentrated in epidermal chromatophores[1]. In view of much evidence from other forms of a relationship between the occurrence of melanin and phenolases, evidence of such enzymes in *Diadema* was sought.

Cœlomic fluid removed from the animal forms a colourless slimy clot of aggregated cœlomic amœbocytes, which rapidly changes to red, and then, as in 'Thyone'[2], slowly becomes brown or black. In *Diadema*, the process involves oxidation, since it is hastened by aeration and prevented if the fluid is exposed in nitrogen. The pigment produced has the characteristics of melanin.

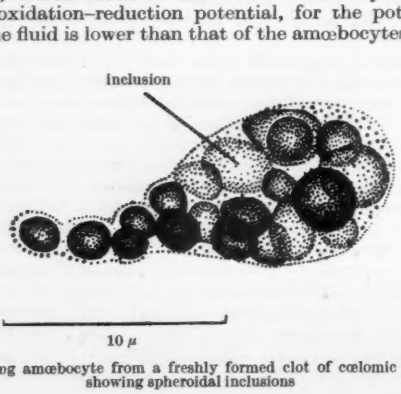
Darkening is inhibited by boiling and by 0·0003 *M* potassium cyanide, and thus appears to be an enzymatic process involving oxidases. Phenolases are indicated by the character of the colour change, and the production of coloured oxidation products by the action of the cœlomic fluid on phenolic substrates such as l-tyrosine, dihydroxyphenylalanine, pyrocatechol, *p*-amino phenol, quinol and pyrogallol, buffered within the *p*H range 6·5–7·4. The reactions are accelerated by detergents. As reported by Pugh and Raper[3] for mealworm phenolases, the enzyme system does not act on quinol at *p*H 7·0 unless the solution is dilute (0·0002 *M* in *Diadema*).

Other features of these colour reactions indicating participation of phenolases are activation by ultraviolet light and inhibition by 0·0002 *M* potassium cyanide and hydrogen sulphide. 3 *M* Ethanol and 4 *M* methanol are usually inhibitory, though not invariably so. It is highly significant that darkening of the clot in cœlomic fluid is similarly affected by these factors, and further, it is usually, but not always, inhibited by *p*-benzyl-hydroquinone ('agarite alba').

The enzymes are not part of the cytochrome–cytochrome oxidase system, since they are soluble in water, unaffected by 0·002 *M* sodium azide at *p*H 7·3 and only slightly affected by acetone.

There is thus evidence of both monophenolase and polyphenolase activity in the cœlomic fluid.

Both activities are shown by the clot alone, and both are markedly increased when it is removed from the fluid and later replaced in the same fluid which has been boiled and cooled. This indicates the presence of a heat-labile inhibitory factor in the fluid, which could be associated with a system of low oxidation–reduction potential, for the potential of the fluid is lower than that of the amœbocytes.



Living amœbocyte from a freshly formed clot of cœlomic fluid showing spheroidal inclusions

Darkening of the clot on exposure to air is due to blackening of spheroidal or discoidal cytoplasmic inclusions in the amœbocytes (see diagram), which occurs whether the inclusions be *in situ*, or free, following breakdown of the amœbocytes after centrifuging and shaking. They therefore appear to play an essential part in pigment production, embodying enzyme, substrate, or both. The fact that they also blacken after intra-cœlomic injection of dihydroxyphenylalanine in sea water affords further indication that they contain the enzyme system. A varying proportion of the inclusions are bright red; but the significance of the red pigment in relation to their subsequent blackening is obscure. Should it transpire to be an echinochrome, it may prove of importance in view of the participation of these and similar compounds in reversible oxidation–reduction systems (Cannan[4]), and the importance of such systems in regulating melanogenesis[5].

A full account of the investigation will be published elsewhere.

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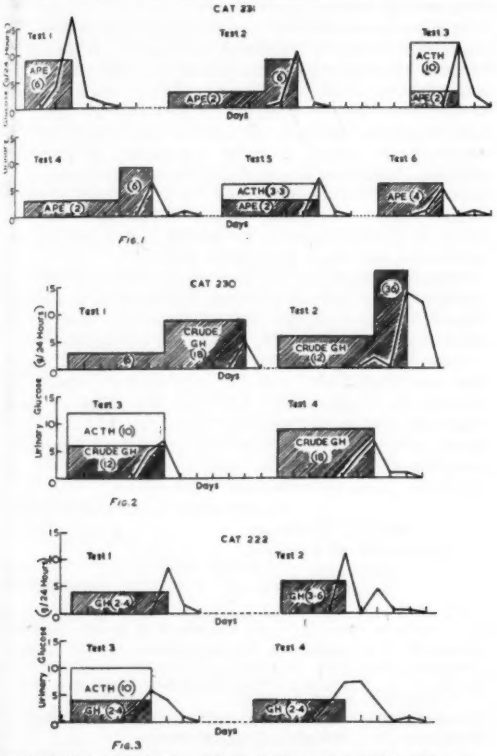
Potentiation by Adrenocorticotrophin of the Diabetogenic Action of Growth-Hormone Preparations

The adrenocorticotrophic hormone is not a potent diabetogenic agent in the intact cat[1], in contrast to growth hormone. Its influence on the diabetogenic activity of growth-hormone preparations in the intact cat has now been studied, as briefly reported elsewhere[2].

The growth-hormone preparations were derived from ox anterior pituitary glands, and included crude extracts and purified products[3]. The growth-hormone content of the former was assayed in adult female rats[4]. The adrenocorticotrophic hormone preparation employed in the present experiments was derived from pig pituitary glands, and had a potency 2·5 times that of the Armour standard (ascorbic acid depletion). Both preparations were given subcutaneously, at different sites, to intact adult male cats fed on a meat diet, the intake of which varied little from day to day[5]. In each test, treatment was continued until a glucose excretion exceeding 5 gm. in 24 hr. ('5-gm. response'[5]) had been induced. The growth-hormone preparation was given once daily, and the other preparation usually three times daily (during eight hours).

In a given cat there is an inverse relationship between the dose of a diabetogenic preparation and the period of treatment required to induce the '5-gm. response'[5]. Thus, in control experiments with a crude extract in cat 231 (tests 1 and 2, Fig. 1), a daily dose of 6 mgm. (expressed as growth hormone) was effective in three days, and one of 2 mgm. (trebled after six days) was effective only after eight days of treatment. When, however, the growth-hormone preparation was given at a daily dose of 2 mgm. in

conjunction with adrenocorticotrophic hormone, the response was obtained in only three days. Since the subsequent control test showed that the sensitivity of the cat to the growth-hormone preparation alone had not changed, it was concluded that the adrenocorticotrophic hormone had potentiated its diabetogenic action. Tests 5 and 6, in conjunction with the preceding tests, indicate that adrenocorticotrophic hormone given at a reduced dose, only once daily, still had some potentiating action.



Potentiation experiments using adrenocorticotrophic hormone (*ACTH*) with: (1) crude anterior pituitary extract (*APE*) in cat 231; (2) a crude growth-hormone preparation (= crude *A* fraction of Wilhelmi *et al.*[3]) in cat 230; (3) a purified growth-hormone preparation in cat 222. Period of treatment denoted by rectangle, the height of which is, for each cat, proportional to the daily dose (also indicated numerically). Doses expressed as mgm. of growth hormone (*GH*) or, in the case of adrenocorticotrophic hormone, as mgm. of Armour standard

In cat 230 (Fig. 2), with a crude growth-hormone preparation, 12 mgm. given with adrenocorticotrophic hormone (test 3) was as effective as 18 mgm. given without the latter with respect to the period of treatment required to induce the response. A smaller, but probably significant, potentiating action of adrenocorticotrophic hormone was observed in cat 222 (Fig. 3) with a purified growth-hormone preparation. In this experiment, 2·4 mgm. of growth hormone given with adrenocorticotrophic hormone (test 3) was more effective than 2·4 mgm., but less effective than 3·6 mgm., of growth hormone given alone.

It is concluded that the diabetogenic action of growth-hormone preparations in the intact cat may be augmented by adrenocorticotrophic hormone given simultaneously. While the investigation was in progress, Engel and co-workers[6] briefly reported that growth hormone is diabetogenic in the force-fed rat if adrenocorticotrophic hormone is given simultaneously, although growth hormone alone is not a potent diabetogenic agent in the rat.

My experiments were performed during the tenure of a Beit Memorial fellowship. The costs were largely defrayed by a grant from the Medical Research Council to Prof. F. G. Young, to whom I am indebted for his interest and encouragement. Thanks are expressed to Drs. I. M. Bunding, E. E. Hays and J. R. Mote, of Armour and Co., Chicago, for providing adrenocorticotrophic-hormone preparations, and to Prof. A. E. Wilhelmi for advice on the preparation of growth hormone. For technical assistance, thanks are expressed in particular to Mr. M. Snowdon.

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Low Toxicity of the Diphtherial Culture Filtrate and its Relation to the Absence of Tyrosine in the Medium

I HAVE already shown[1] that the diphtherial culture filtrate harvested from the chemically defined media (A.M.C. and A.M.T. medium) containing two (asparagine, DL-methionine) or three amino-acids (asparagine, DL-methionine and L-cystin) as a nitrogen source had a very low toxicity for guinea pigs, while it showed a high degree of flocculation units.

While searching for the causes of this phenomenon, it has been observed that the presence of tyrosine in culture medium plays an important part in controlling the toxicity of the diphtheria toxin produced. Typical results are given in Table 1. It will be seen that the median lethal dose per flocculation unit of the culture filtrate harvested from the medium containing tyrosine is about 35–100, whereas it is only 3–18 when tyrosine is absent.

Table 1. EFFECT OF THE PRESENCE OF TYROSINE IN MEDIUM ON THE TOXICITY OF THE CULTURE FILTRATE OF *C. diphtheriæ*

Tyrosine (0·1 gm./l. of medium)	Exp. No.	Toxin content (Lf./ml.)	Toxicity (M.L.D.)	M.L.D./Lf.
Absent	1	20	100	5
	2	30	100	3
	3	28	100	4
	4	56	1,000	18
	5	60	500	8
	6	90	500	5
Present	1	10	1,000	100
	2	20	1,500	75
	3	17	1,500	86
	4	28	1,000	35
	5	40	2,000	50
	6	45	2,000	45

The A.M.T. medium used throughout this work was prepared by my method[2] with careful adjustment of starting *p*H (7·0) and iron concentration (1–2γ/30 ml. of medium), and its composition was as shown in Table 2. Tyrosine dissolved in phosphate buffer (*p*H 7·0) was added to the medium just before inoculation (0·1 gm./litre of medium).

Table 2

Asparagine	5·0 gm.
DL-Methionine	0·3 gm.
Sod. thioglycollate	0·6 gm.
Pot. dihyd. phosphate	5·0 gm.
Calcium chloride	1·0 gm.
Sodium chloride	4·0 gm.
Maltose	12·5 gm.
Sod. lactate	1·75 gm.
Mueller's II solution (ref. 3)	2·0 ml.
Aqua redest.	1,000 ml.

After inoculation with the pellicle from a four-day old culture of a sub-strain (adapted to the synthetic medium mentioned above) of *P.W.* No. 8 (Toronto Harvard) strain and eight or nine days incubation at 33–35° C., flocculation units and median lethal dose for guinea pigs (250–260 gm.) belonging to a vigorous stock were determined.

In 1943, Seki[4] described his finding that the removal of the crystalline (tyrosine) formed during the preparation of casein acid-hydrolysate tends to decrease the toxin content (from the estimation of median lethal dose) of the culture filtrate harvested from the casein hydrolysate medium; and Linggood and Woiwod have recently shown that tyrosine is present in toxin but not in toxoid hydrolysate of diphtheria on two-dimensional paper chromatograms[5]. Therefore, the possibility of an intimate connexion between the toxic group of diphtheria toxin and tyrosine present in the culture medium may be supposed, but the intrinsic significance of tyrosine is not yet clear. Further work to find the actual mechanism involved is now in progress. This will be published in detail later.

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Factor *Rb* Activity in Human Plasma

Factor *Rb* is a protein-like, heat-labile requirement of the nematode *Rhabditis briggsae* Dougherty and Nigon, 1949, for growth and reproduction under axenic conditions[1,2]; chick embryo and mammalian liver have been shown to be good sources of it, and some activity has previously been noted in human whole blood and plasma[2].

It is of interest to report now that, when properly supplemented, human plasma has been shown, by recent work, to be a good source of factor *Rb*. The plasma used was obtained through the courtesy of Dr. Karol A. Hok, of the Cutter Laboratories, Berkeley; it was irradiated, lyophilized material, pooled from many donors and with approximately 0·4 per cent sodium citrate included as an anticoagulant. Water was added to restore the original volume, and the liquid was sterilized by Seitz filtration. Part of the sterile product was dialysed under sterile conditions against three changes of a large volume of distilled water. Both the dialysed and undialysed material were tested as sources of factor *Rb*. This was done by adding to each of a series of *Neurospora* growth-tubes 1 ml. of one of the plasma preparations and 1 ml. of an autoclaved liver preparation made by homogenizing horse liver with an equal weight of distilled water, centrifuging the product at 20,000 *g*, autoclaving the supernatant fluid, homogenizing the product, recentrifuging at 20,000 *g*, and sterilizing the clear supernatant by passing it through a Seitz filter.

The foregoing media have uniformly supported the production of vigorous cultures inoculated with a few dozen tiny larvæ. These results are in contrast to limited growth (maturation without successful reproduction) of larvæ placed in plasma supplemented with certain known ingredients[3].

The newer results are particularly significant for the development of a defined medium for *R. briggsae*, because the protein constitution of human plasma is the best known of any complex biological material[3]. It will now become possible to test the plasma protein fractions already available and probably to determine in which of these the factor *Rb* activity resides. This has a great advantage over extending the tedious fractionation of liver protein already carried out[3,4]. It may supply a rationale for the failure of peptic digestion to release factor *Rb* activity in non-protein form from liver protein[5].

The foregoing preliminary results are reported at this time by reason of the fact that further investigations on plasma protein will probably be delayed for more than half a year by projected travel abroad.

Note added in proof. My student, Douglas F. Keith, has recently been able to show that factor *Rb* activity is apparently confined to those plasma fractions rich in β-globulins (fractions III and IV). He is now testing subfractions of these fractions, particularly as supplemented only by known ingredients (that is, vitamins, salts, etc.).

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The Rabbit Lumbrical: a New Isolated Mammalian Nerve-Muscle Preparation

The rat diaphragm phrenic nerve preparation[1] enabled mammalian muscle to be studied under precise conditions of drug and ion concentration, but is insensitive to decamethonium (*C*10). The object of this communication is to describe a new isolated mammalian nerve-muscle preparation which does not suffer from this disadvantage. Several muscles in the feet of rabbits and cats are suitable; but the medial lumbrical of the rabbit's hind foot has been found most satisfactory. It is usually about 18 mm. long and 1 mm. in diameter under physiological tension.

A rabbit is killed and bled, and the skin removed from one hind leg. It is very adherent on the plantar surface of the foot and must be carefully removed, since the nerve is immediately beneath it.

The long, very fine tendon of insertion of the medial lumbrical which passes around the medial side of the second digit is secured by a piece of silk and cut distally. Next the plantaris tendon passing to the

second digit is separated and removed, allowing the lateral side of the muscle to be freed back to its origin from the junction of the medial two tendons of flexor digitorum longus.

The tibial nerve is dissected distally to the point where it splits into a sheaf of branches which turn diagonally to cross the plantaris tendons, and gently retracted laterally, to allow the medial plantaris tendon to be carefully separated and removed. The medial side of the muscle can now be freed up to its origin, and the part of the tendon from which the muscle arises is cut out with the muscle attached. This lumbrical is occasionally vestigial or absent, and variations in the nerve supply sometimes occur.

Directly and indirectly elicited contractions are equal in height provided the nerve is undamaged, although there may be some degree of temporary initial block, presumably due to anoxia during the dissection.

Using a weight-loaded lever designed to act ballistically, records of the order of 8 cm. in height are regularly obtained.

A gas mixture consisting of 95 per cent oxygen and 5 per cent carbon dioxide is used, and the temperature is maintained at 39° C. The preparation is sensitive to both *d*-tubocurarine and decamethonium. The reaction to decamethonium and sensitivity to both drugs are, however, very dependent on temperature and ionic concentration. At a stimulus-rate of about eight a minute, the preparation continues to contract without reduction in height or neuromuscular block for prolonged periods of time.

This investigation was supported by a grant from the Research Committee of the University of California Medical School, San Francisco.

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Selenium Toxicity associated with an Irish Soil Series

For a number of years a disorder in livestock has set a considerable farming problem in a district in County Limerick. In horses, this disorder in its severe form is shown by the loss of hair from mane and tail, with alteration in the growth, and eventually loss, of hooves. Horses affected in this way 'go down', while the less severe form of this condition is reflected in hoof deformation.

In cattle there is also alteration in the growth of hooves, with eventually the sloughing off of the old hooves and in some cases loss of the tail. The cattle thus affected show poor condition.

Due to loss and alteration of the growth of hooves, affected cattle find difficulty in moving about and in some cases assume a kneeling position when grazing.

An examination of soil and herbage samples has revealed nothing unusual with regard to major or minor elements, while blood samples analysed by Dr. O'Moore of the Veterinary Research Laboratory showed normal levels of sugar, phosphorus, calcium, magnesium and copper. Due to the similarity of this condition to that described by American workers[1,2] as typical of selenium toxicity, soil and herbage samples were examined for selenium content by the method of Dr. W. O. Robinson[3], whose advice[4] we gratefully acknowledge.

These analyses have shown that the selenium content of soil from affected fields varies between 30 and 324 p.p.m., whereas samples from immediately adjoining healthy soils gave values of less than 2 p.p.m. The selenium content of mixed herbage samples from affected areas gave values varying from 150 to 500 p.p.m., the latter figure being obtained from the soil showing the highest selenium content. Analyses of herbage samples from immediately adjoining non-affected fields gave values less than 1 p.p.m. By comparison with American figures for highly selenized areas, the selenium level of soils reported here is extremely high, while that for herbage is well above the limit of 5 p.p.m. stipulated as being marginal for toxicity, especially when it is considered that the analyses were on ordinary mixed-herbage samples. There would seem to be no doubt, therefore, that this condition is due to selenium toxicity.

The soils affected are low-lying valley soils in a glaciated area where the underlying rock strata consist of Upper Carboniferous Limestone. They are dark grey fine sandy loams to medium loams with the organic carbon content varying from 5 to 15 per cent and ranging in reaction from slightly acid to alkaline. In general, drainage is somewhat impeded and manganese deficiency in cereals is a problem on some of these soils. Rainfall at 40 in. a year is moderately high. From this description it can be seen that the affected soils differ considerably from those described for seleniferous areas in the United States. The normal soils at higher elevation in this area are brown to grey-brown fine sandy loams to medium loams, quite fertile, and from the data so far available do not appear to have been selenized.

There is evidence to suggest that the formation of affected soils has been considerably influenced by wash from Yoredale Beds (Avonian shales) which lie immediately to the west of the affected area. From Geological Survey data available, it would appear that these beds contain considerable deposits of iron pyrites, a circumstance of importance when explaining the presence of selenium, as from the American work it would appear that pyritiferous shales may be rich sources of selenium.

Preliminary botanical examinations carried out have failed to reveal anything unusual in the composition of the herbage, especially in relation to the occurrence of selenium accumulators, of the pasture swards of affected areas.

Experimental work on a field- and laboratory-scale is proceeding, and the results will be published elsewhere in due course.

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Heat Tolerance in European Breeds of Cattle Exposed to High Environmental Temperatures

Messrs. A. L. Badreldin, M. M. Oloufa and M. Abdel Ghany have reported observations on heat tolerance of cattle at Giza (*Nature*, **167**, 856; 1951).

In the Singapore Dairy Farm, where more than six hundred head of Ayrshire, Holstein and Shorthorn cattle are kept as a commercial dairy herd, it has been possible to record rectal temperatures and respiration-rates of groups of fifty cows at hourly intervals for periods of seven days throughout the past nine months.

It is considered that the comparison of average air temperatures, etc., with average rectal temperatures and respiration-rate cannot produce information of much value. Clinical evidences of heat intolerance develop only when the rate of heat production within the body exceeds the rate at which heat can be lost to the exterior. The critical environmental temperature productive of a state of adverse heat exchange varies with the degree of air movement and ventilation. Further, the magnitude of the effects of exposure to high temperatures is dependent upon how far the critical temperature is exceeded and for how long.

In this herd, where normally air movement is negligible, rectal temperature commences to rise when that of the surrounding air reaches 78° F.; after one hour's exposure it averages 101·78° F. but after four hours exposure it averages 102·23° F. Two hours exposure to a byre temperature of 94° F. results in an increase to 104·45° F. If heat loss is assisted by hourly sprinkling with water and blast fans, byre temperatures of up to 89° F. cause no appreciable rise in rectal temperature.

Respiration-rate at all temperatures below 78° F. never exceeds 50 per minute; but above that temperature it rises progressively to 130 per minute at 94° F.

Accurate figures for pulse-rates of groups of cattle are extremely difficult to obtain, due to the disturbance necessitated during such mass examinations. However, indications are that pulse-rate is not depressed during heat stress unless it is severe, and that the converse is normally the rule.

It has been impossible to demonstrate any correlation between humidity and temperature regulation.

Preliminary findings on fifty-seven head of cattle would indicate that the chloride-level of the blood plasma rises during exposure to high environmental temperatures, tending to support the supposition that in European types of cattle water-loss is by evaporation through the lungs and diffusion through the skin rather than by direct sweating.

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Tone Sensation produced by Repetitive Trains of Auditory 'Click' Stimuli

It is well known that a sensation of continuous tone may be produced by presenting to the ear regularly repeated trains of sinusoidal waves, although each train may consist of only a few oscillations followed by a relatively long 'blank' period[1]. I have observed that a sensation of tone may arise by the presentation of trains of very short pulses, each pulse of duration of 0·20 m.sec., and each train consisting of two such pulses only. The pulse duration quoted is that measured on a cathode ray oscilloscope across the output of the amplifier, no suitable instrument being available to monitor the air pressure wave-form as produced by the loud-speaker. The pulses were derived from an electronic stimulator, and were locked to the time-base at predetermined times, each being independently adjustable. Hence, for each time-base two pulses were obtained, the separation of which in time could be varied from zero (coincidence) to 10 m.sec. The time-base repetition-rate could be varied from 10 to 100 per sec. Within this range, at any given rate of repetition, progressive separation of the pulses gave rise to a sensation of falling pitch, and approximation caused a rising pitch. At a separation of 1 m.sec., the sensation was that of a 1,000-cycle per sec. tone, as matched against a known frequency source; at a separation of 2 m.sec. the tone was 500 cycles per sec., at 4 m.sec. 250 cycles per sec., and so on. Since the tone sensation dependent on the pulse separation was heard against a background due to the frequency of repetition of each pulse (the time-base repetition-rate), only those derived tones of frequency considerably higher than the frequency of repetition could readily be detected and matched against the standard frequency source.

A simple theoretical interpretation of the phenomenon, based on the local resonator theory of auditory perception, may be offered. We assume that the first pulse of each pair, being of short time-duration compared with the tone sensation being studied, and having an abrupt initial rise, produces shock excitation of a wide band of resonators extending over the normal auditory spectrum. The second pulse arriving after an interval t will tend to augment the amplitude of resonators which have just completed integral numbers of complete cycles, that is, those of natural periods t, $t/2$, $t/3$, etc. Resonators of period $2t$ will be suppressed, having completed half a cycle and receiving the second pulse in anti-phase. Resonators of other periods will be either only partially or not affected. Since of those which are selectively augmented (periods t, $t/2$, $t/3$, etc.) the decrement due to frictional losses will be progressively higher for the higher harmonics, the fundamental (t) and lower harmonics will predominate, giving a tone sensation identified as of period t (frequency $1/t$). The theory predicts that inversion (phase reversal) of the second pulse should result in selective augmentation of resonators of period $2t$, and suppression of those of period t. Preliminary experiments indicate that this occurs, in that the tone sensation falls in pitch by an octave when the second pulse is suddenly inverted. Since the tone sensation derived depends upon repetitive presentation of trains of two pulses (that is, a single presentation gives no sensation of the tone described), the observation seems to suggest a relatively slow decrement of the energy stored in a given resonator, which is not completely dissipated before the arrival of the next train in a sequence. This offers further support to the view of Pumphrey and Gold that the resonator elements of the cochlea possess a high Q factor. It is intended to modify the apparatus in order to study the phenomenon over a wider range of conditions.

W. T. Catton

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Newcastle upon Tyne. June 12.

[1] Pumphrey, R. J., and Gold, T., *Nature*, **160**, 124 (1947); *Nature*, **161**, 640 (1948); *Proc. Roy. Soc.*, B, **135**, 462 (1948).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 19

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Light Electrical Engineering and the Mechanical Engineer" (to be opened by Mr. T. E. Goldup).

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Great Hall, College of Technology, Manchester), at 5.30 p.m.—Sir John Cockcroft, F.R.S.: "The Industrial Applications of Atomic Energy and its Products" (Joule Memorial Lecture).*

SOUTH-EAST LONDON TECHNICAL COLLEGE (at Lewisham Way, London, S.E.4), at 7 p.m.—Mr. P. Grodzinski: "Diamonds in Physical Instruments".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—M. André Liotard: "French Explorations in Antarctica".

Tuesday, November 20

CHADWICK PUBLIC LECTURE (at the Royal Sanitary Institute, 90 Buckingham Palace Road, London, S.W.1), at 2.30 p.m.—Prof. William Holford: "The Health of Cities—Some Problems arising from Congestion and Overbuilding" (Bossom Gift Lecture).*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. F. E. Zeuner: "Dating the Past". (Further Lectures on November 27, December 4 and 11.)

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Symposium on "Voluntary Sterilization" (Speakers: Dr. C. P. Blacker, Mrs. Moya Woodside, Mr. Cecil Binney).*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. F. C. Williams, F.R.S., Dr. T. Kilburn, Mr. G. C. Tootill, Mr. G. E. Thomas and Dr. A. A. Robinson: Papers on "Universal High-Speed Digital Computers": Prof. F. C. Williams, F.R.S., and Mr. J. C. West: "The Position Synchronization of a Rotating Drum".

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. D. M. Newitt, F.R.S.: "Recent Trends in Chemical Engineering".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. A. W. Downie: "The Scientific Basis of Medicine, 13, Antibodies and Immunity to Virus Infection".* (Further Lectures on November 23, 27 and 29, December 4, 6 and 11.)

MANCHESTER GEOGRAPHICAL SOCIETY (at the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Major William Cross: "Reflexions upon Amazonian Exploration".

TEXTILE INSTITUTE, YORKSHIRE SECTION (joint meeting with the WEST RIDING SECTION of the SOCIETY OF DYERS AND COLOURISTS, at the Midland Hotel, Bradford), at 7.15 p.m.—Dr. C. S. Whewell: "The Finishing of Cloths containing Wool and Synthetic Fibres".

Wednesday, November 21

ROYAL MICROSCOPICAL SOCIETY (in the Great Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 2.30 p.m.—Exhibition of "How Industry is Using the Microscope".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. L. Dudley Stamp: "The Reclamation of Abandoned Industrial Areas".

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Mr. W. P. Nicol: "Telecommunications in Aviation".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. R. C. Mildner: "Developments in High Frequency Transmitter Cables".

MANCHESTER METALLURGICAL SOCIETY (at the Engineers' Club, Albert Square, Manchester), at 6.30 p.m.—Mr. W. Ramsden: "Spectrographic Analysis".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (joint meeting with the BIRMINGHAM AND MIDLANDS SECTION, in the University Mason Theatre, Edmund Street, Birmingham), at 6.30 p.m.—Mr. J. Welsh: "Corrosion in Gas Burning Appliances".

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. F. Chapman: "Petroleum Chemicals and the Paint Industry".

SCIENCE FOR PEACE (at the small Conway Hall, Red Lion Square, London, W.C.1), at 8 p.m.—Prof. J. B. S. Haldane, F.R.S., and Prof. C. F. Powell, F.R.S.: "The Threat to Science".

Wednesday, November 21—Thursday, November 22

IRON AND STEEL INSTITUTE (at 4 Grosvenor Gardens, London, S.W.1), at 10 a.m. each day.—Autumn Meeting.

Thursday, November 22

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. E. Smailes: "The Geographical Study of Towns".*

UNIVERSITY OF LONDON (at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5), at 3 p.m.—Dr. W. Grey Walter: "The Relationship between the Electrical Activity of the Brain and Adaptive Behaviour".*

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. I. H. Burkill: "Habits of Man and the Origins of the Cultivated Plants of the Old World" (Hooker Lecture).

BRITISH ORNITHOLOGISTS' UNION (at the Zoological Society of London, Regent's Park, London, N.W.8), at 5.30 p.m.—General Meeting; at 6 p.m.—Dr. A. J. Cain: "Selection and Evolution in the Parrot *Trichoglossus*".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. W. Fordham Cooper: "Electrical Control of Dangerous Machinery and Processes, Part 3, Remote Supervisory Control".

RESEARCH DEFENCE SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Sir Wilson Jameson, G.B.E.: "Research and Administration—a Profitable Partnership?" (Twentieth Stephen Paget Memorial Lecture).

ROYAL AERONAUTICAL SOCIETY (at St. Mary's College, Cheltenham), at 7.30 p.m.—Mr. A. N. Clifton: "Problems of Transonic Flight".

TEXTILE INSTITUTE, MACCLESFIELD, LEEK AND DISTRICT SECTION (at Conlowe, Ltd., Canteen, Congleton), at 8 p.m.—Anne M. Buck: "History of Costume".

Friday, November 23

LIBRARY ASSOCIATION (at Chaucer House, Malet Street, London, W.C.1), at 11 a.m.—Discussion on the Library Association Working Party's Interim Report on "The Co-operative Provision of Books, Periodicals and related Material in Libraries".

BRITISH SOCIETY OF RHEOLOGY (at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 2.30 p.m.—Mr. J. Evans: "The Strength of Soils in relation to the Performance of Cross-Country Vehicles": Mr. P. Payne: "Some Problems in applying Soil Mechanics to the Action of Cultivation Implements".

PHYSICAL SOCIETY, ACOUSTICS GROUP (at the Royal Institute of British Architects, 66 Portland Place, London, W.1), at 4.30 p.m.—Discussion on "The Acoustics of the Royal Festival Hall" (to be opened by Mr. P. H. Parkin and Mr. W. A. Allen).

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Earth Tides". (Speakers: Prof. Harold Jeffreys, F.R.S., Prof. R. Tomaschek, Dr. B. Baars and Dr. R. H. Corkan.)

CHEMICAL SOCIETY, NEWCASTLE AND DURHAM SECTION (in the Chemistry Building, King's College, Newcastle-upon-Tyne), at 5.30 p.m.—Prof. R. P. Linstead, F.R.S.: "The Transfer of Hydrogen between Organic Compounds" (Bedson Club Lecture). (All Fellows are invited.)

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. Llewellyn Young: "The Control of Boilers Fired by Solid Fuels in Suspension".

MANCHESTER STATISTICAL SOCIETY, STATISTICAL METHODS STUDY GROUP (at the Albert Hall, Peter Street, Manchester), at 5.30 p.m.—Mr. G. H. Goode: "Technical Problems in calculating the Retail Price Index Number".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. A. A. Miles: "The Scientific Basis of Medicine, 14, Bacterial Aspects of Immunity".* (Further Lectures on November 27 and 29, December 4, 6 and 11.)

GEOGRAPHICAL ASSOCIATION, MANCHESTER BRANCH (in the Geography Room, Central High School for Boys, Whitworth Street, Manchester), at 6 p.m.—Mr. N. G. Fisher: "The Influence of Geography on Foreign Policy" (Presidential Address).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Dr. J. E. Richards: "An Analysis of Ship Vibration using Basic Functions".

TELEVISION SOCIETY (at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Mr. K. J. Easton: "Television Distribution by Wire".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. J. A. Ratcliffe, F.R.S.: "Radio-Astronomy".

Saturday, November 24

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Sir Richard Winstedt: "The Malay Races down the Centuries".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN METALLURGY, and an ASSISTANT LECTURER IN PHYSICS, at Rotherham Technical College—The Director of Education, Education Offices, Rotherham (November 24).

EXPERIMENTAL OFFICER, Grade III, IN THE LONG RANGE WEAPONS ESTABLISHMENT, Adelaide, to be responsible to a Senior Scientific Officer for the work of a team engaged in the application of photo and cine theodolites, instrument recording cameras and other special cameras, to ballistics and other aerodynamic problems—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (November 24).

HEAD OF THE TEXTILE DEPARTMENT, BOLTON TECHNICAL COLLEGE—The Chief Education Officer, Education Offices, Nelson Square, Bolton (November 24).

Deputy Fisheries and Pollution Officer—The Clerk to the Devon River Board, The Castle, Exeter (November 30).

Senior Lecturer in Civil Engineering (Structures) at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (December 7).

Scientist, Grade II (with a good university honours degree or equivalent in chemistry or physics, chemical engineering or fuel technology) on the staff of the Director of Scientific Control at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/393 (December 8).

Scientists, Grade III (with a good honours degree, or equivalent, in science, mathematics or engineering) for operational research posts in the Field Investigation Group of the Directorate of Scientific Control—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/395 (December 8).

Statisticians at a Ministry of Supply research establishment in the South of England for duties involving statistical advice on the design and results of experimental work in microbiological research, particularly in the fields of bacteriology and experimental pathology, biophysics and biochemistry—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4102/51 (December 13).

Reader in Clinical Veterinary Medicine at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (December 15).

Lecturer in Geography at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (December 31).

Tucker-Price Scientific Research Fellowship, for research in mathematics, science or an allied subject—The Secretary, Girton College, Cambridge (January 15).

Assistant Lecturer in the Department of Mathematics—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

Botanist (with honours degree) to undertake the investigation of marine ecological problems—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

Electrical Engineers (Experimental Officer grade) at the Royal Aircraft Establishment, Farnborough, for work on aircraft electrical generating equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.425/51A.

Electrical Engineers and Physicists at a Ministry of Supply research and development establishment near London—Senior Scientific Officers: Electrical Engineers (Ref. D.39/51A) with special qualifications in radio communications and experience in the engineering of development prototypes, Physicist (Ref. A.245/51A) with experience in electronic circuitry for research into the measurement of high-speed transients, and a Physicist (Ref. 246/51A) with experience of optical and electronic techniques, and with an interest in fluid mechanics, for work on aerodynamics problems including wind tunnel investigations; Scientific Officers: Electrical Engineer or Physicist (Ref. D. 392/51A) with interest in the application of electronic methods to optical instrumentation techniques, and an Electrical Engineer or Physicist (Ref. D.391/51A) for work on high-speed electronic calculating machine—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

Electrical and Mechanical Engineers and Physicists (Experimental Officer grade), with experience in (*a*) generation and distribution of electrical power in aircraft, (*b*) general electronics, communication or radar, (*c*) aircraft structure and associated mechanical problems, or (*d*) servo mechanisms and automatic actuators, at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.483/51A.

Engineer (with specialized experience in electronic engineering, servo mechanisms, or fine mechanisms including hydraulic devices) at a Ministry of Supply establishment at Malvern, to take charge of a team of engineers investigating engineering and design problems, working with scientific staff on development of ground radar equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.482/51A.

Engineering Officer (Wireless) in the Posts and Telegraphs Department, Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Engineering Officer (Wireless), 4/58'.

Experimental and Assistant Experimental Officers at the Ministry of Supply Factory, Capenhurst, Chester, for research work connected with the construction and operation of an atomic energy factory—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

Graduate Lecturer in Electrical Engineering at Lincoln Technical College—The Chief Education Officer, City Education Office, 4 Lindum Road, Lincoln.

Head of the Department of Engineering and Mining at Wakefield Technical College—The Director of Education, 27 King Street, Wakefield.

Head of the Electrical Engineering Department—The Registrar, Loughborough College, Loughborough, Leics.

Horticultural Superintendent—The Principal Agricultural Officer, Lancashire County Institute of Agriculture, Hutton, Preston.

Lecturer (with a university degree in engineering, or equivalent qualification, and practical experience in the electrical industry) in the Electrical Engineering Department—The Principal, Northampton Polytechnic, St. John Street, London, E.C.1.

Mechanical and Electrical Engineers (New Construction) in the Public Works Department, Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Mechanical Electrical Engineer 4/320'.

Physical Chemists in the Division of Atomic Energy (Production), Research and Development Branch, Culcheth, Warrington, to assist in research on corrosion, electrochemistry, thermochemistry, surface chemistry and constitution of alloys—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

Physicists at a Ministry of Supply research establishment in Berkshire for work of a research and development character concerned with the use of radioactive materials, radiation measurements and health physics—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.333/51A.

Science or Engineering Graduates to do research on some aspects of the flow of liquids through porous surfaces—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Tenth Report of the Commissioners for the Exhibition of 1851. Pp. 41. (London: Royal Commission for the Exhibition of 1851, 1951.) [49

National Physical Laboratory. Notes on Applied Science, No. 1: Gauging and Measuring Screw Threads. Pp. vi+109+7 plates. (London: H.M. Stationery Office, 1951.) 5*s.* net. [49

Committee for Commonwealth University Interchange. Report for the Two Years ending 31st March 1951. Pp. 16. (London: British Council, 1951.) [49

British Society for the Promotion of Vegetable Research. First Annual Report 1950 (October 1949–September 1950). Pp. viii+60. (Wellesbourne, Warwick: National Vegetable Research Station, 1951.) [59

Northern Advisory Council for Further Education. Fourth Annual Report, 1950–1951. Pp. 43. (Newcastle-upon-Tyne: Northern Advisory Council for Further Education, 1951.) [59

Other Countries

United States Department of the Interior: Geological Survey. Bulletin 955-D: Gold Placers and their Geologic Environment in North-western Park County, Colorado. By Quentin D. Singewald. (Contributions to Economic Geology, 1947.) Pp. vi+103–172+plates 8–17. 1.25 dollars. Bulletin 962-D: Tin Deposits of Durango, Mexico. By Ward C. Smith, Kenneth Segerstrom and Reinaldo Guiza, Jr. Pp. iv+155–204+plates 32–49. n.p. Bulletin 963-D: Photo Interpretation of the Terrain along the Southern Part of the Alaska Highway. By Hugh M. Raup and Charles S. Denny. (Mineral Resources of Alaska, 1945–46.) Pp. iv+95–136+plates 9–16. 55 cents. Bulletin 964-D: Geology and Mineral Resources of the Maimón-Hatillo District, Dominican Republic. By A. H. Koschmann and Mackenzie Gordon, Jr. Pp. v+307–360+plates 18–19. 75 cents. Bulletin 964-E: Quicksilver Deposits of Chile. By J. F. McAllister, Hector Flores W., and Carlos Ruiz F. (Geologic Investigations in the American Republics, 1949.) Pp. vi+361–400+plates 20–30. 75 cents. Bulletin 969-A: Diamond-Drill Exploration of the Dillsburg Magnetite Deposits, York County, Pennsylvania. By Preston E. Hotz. (Contributions to Economic Geology, 1949–50.) Pp. iv+28+10 plates. 70 cents. Bulletin 969-B: Corundum Deposits of Gallatin and Madison Counties, Montana. By S. E. Clabaugh and F. C. Armstrong. (Contributions to Economic Geology, 1949–50.) Pp. iii+29–53+plates 11–15. 75 cents. Bulletin 969-D: The Blewett Iron-Nickel Deposit, Chelan County, Washington. By Carl A. Lamey. (Contributions to Economic Geology, 1949–50.) Pp. iii+87–104+plates 17–19. 65 cents. Bulletin 974-C: Frost Action and Vegetation Patterns on Seward Peninsula, Alaska. By D. M. Hopkins and R. S. Sigafoos. (Contributions to General Geology, 1950.) Pp. iii+51–102+plates 2–3. 40 cents. Bulletin 976-D: Geophysical Abstracts 143, October–December 1950 (Numbers 12340–12513). By Mary C. Rabbitt and S. T. Vesselowsky. Pp. iii+211–266. 20 cents. (Washington, D.C.: Government Printing Office, 1950–1951.) [59

United States Department of the Interior: Geological Survey. Professional Paper 211-E: Geology of the Fort Smith District, Arkansas. By T. A. Hendricks and Bryan Parks. (Shorter Contributions to General Geology, 1949.) Pp. iii+67–94+plates 13–18. 1 dollar. Professional Paper 221-F: Pleistocene Shore Lines in Florida and Georgia. By F. Stearns MacNeil. (Shorter Contributions to General Geology, 1949.) Pp. iii+95–108+plates 19–25. 1 dollar. Professional Paper 221-H: The Habits and Adaptation of the Oligocene Saber Tooth Carnivore, *Hoplophoneus*. By Jean Hough. (Shorter Contributions to General Geology, 1949.) Pp. iii+125–138+plates 26–31. 40 cents. Professional Paper 229: Mica and Beryl Pegmatites in Idaho and Montana. By W. C. Stoll. Pp. v+64+9 plates. 1.50 dollars. (Washington, D.C.: Government Printing Office, 1950.) [59

United States Department of the Interior: Geological Survey. Water-Supply Paper 1050: Quality of Surface Waters of the United States, 1946. Pp. vii+486. 1.25 dollars. Water-Supply Paper 1104: Quality of Water of the Gila River Basin above Coolidge Dam, Arizona. By John D. Hem. Pp. vi+230+2 plates. 1 dollar. Water-Supply Paper 1113: Surface Water Supply of the United States 1948, Part 3, Ohio River Basin. Pp. xiii+750. 1.75 dollars. Water-Supply Paper 1115: Surface Water Supply of the United States 1948, Part 5, Hudson Bay and Upper Mississippi River Basin. Pp. xi+464. 1.25 dollars. Water-Supply Paper 1118: Surface Water Supply of the United States 1948, Part 8, Western Gulf of Mexico Basins. Pp. ix+372. 1 dollar. Water-Supply Paper 1124: Surface Water Supply of the United States 1948, Part 14, Pacific Slope Basins in Oregon and Lower Columbia River Basin. Pp. viii+274. n.p. (Washington, D.C.: Government Printing Office, 1950–1951.) [59